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ABSTRACT

This document presents a systems theory approach to post-secondary education. Terms such as entropy, energy, and "essergy" together with the laws of thermodynamics are applied to educational concepts. A philosophical approach with interspersed quotations from Hegel, Korzybski, and Adelman is used to design a new educational paradigm based upon "Kuhn's Structure of Scientific Revolution." The sections of the document outline the dynamics of education, the three basic needs of man, a systematic approach to a systems approach, educational systems and general systems theory, adoption of a new paradigm, the cost benefit model, energy, entropy, the second law of thermodynamics "essergy," objections and alternatives to a general systems theory approach (to education), personal entropy minimization, individual versus collective entropy reduction, education for the future, and evolution and education. The document includes flow charts, diagrams, and mathematical formulas, together with a 47-item bibliography. (KP)

# TOWARDS 3000: THE DYNAMICS OF FUTURE POST-SECONDARY EDUCATION

BY

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## PREFACE

The purpose of this paper is to stimulate discussion of the future impact of a systems approach to post-secondary education. Entire books such as ADELMAN's "HOLIVERSITY", TROTTER's "TELEVISION AND TECHNOLOGY IN UNIVERSITY TEACHING", and PORTER's "TOWARDS 2000; THE FUTURE OF POST-SECONDARY EDUCATION IN ONTARIO", have emanated from our Universities while the Colleges remain silent. It is Adelman's thesis that the Universities generated the College concept, and perhaps it will remain the nature of the beast that they continue to do our thinking for us.

The opinions expressed in this paper are not necessarily in agreement with those of the College Administration, the College faculty, or for that matter those of the author at some future date.

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# DYNAMICS OF EDUCATION

The word 'DYNAMICS' refers to the effects of the forces or moving agencies in nature. The word 'education' means 'to lead forth.' Consequently, the dynamics of education is concerned with the effects of those motive agencies in nature which lead us forth from our present state of being to other states.

One interesting point that these definitions do not make is that education proceeds from simple states to more complex ones. In fact Chinese water torture or "brain-washing" may perhaps be cited as an example of education where one proceeds from the complex to the simple. Seriously, though, it is quite conceivable that a process exists whereby one is led forth from myriads of confused perceptions and superstitions about reality, into a state of simplified analogic mental models which functionally represent reality, are more easily handled by our limited information processing abilities, and consequently have powerful predictive value. This process would certainly be called 'education'. Thus it is seen that education can proceed as an increase of structure (memorized facts and relationships), and that this increase must at various stages be consolidated into mental packages (sets, groups, formulae etc.) to enable processing of greater quantities of stored information.

## BASIC NEEDS

One of the basic rules of education is that it must help Man to best obtain satisfaction for his basic needs. It should be obvious that if education does not meet any needs, there will be no need for education. The first and most powerful need of biological man is his constant forage for sources of available energy. Primitive man obtained satisfaction by eating berries and roots - forms of stored sunlight or thermo-nuclear radiant flux energy. Apart from mechanizing the picking of berries and the cultivation of roots, man has not yet progressed from this level. Civilized man will finally emerge only when he ceases to be a predator and is no longer dependant upon the long food chains in his ecosystem.

All life-forms (and most emphatically Man), are seekers of available energy. However, not all forms of energy are available to all organisms. For example a turnip can make use of thermo-nuclear radiant flux at certain wave-lengths, to store energy in

## THE BASIC NEEDS OF MAN

| NEED | PRIMITIVE MAN | EDUCATED MAN |
|---|---|---|
| 1. AVAILABLE ENERGY | TURNIPS, SQUIRRELS, BERRIES, BUFFALO MEAT, CANNED TOMATO SOUP, LEMON MERINGUE PIES, TV DINNERS and COCA-COLA | CRUDE OIL, NATURAL GAS, HYDRO POWER, GEOTHERMAL POWER, FISSION ENERGY, FUSION ENERGY, and GRAVITATIONAL ENERGY |
| 2. ENERGY TAPPING METHODS | EATING | INTERNAL COMBUSTION ENGINES, TURBINES, NUCLEAR REACTORS, THERMO-NUCLEAR POWER GENERATORS, PHOTO-ELECTRIC POWER CELLS, GRAVITATIONAL FIELD COLLAPSE POWER GENERATORS |
| 3. GARBAGE DUMPS | OUTHOUSES | AIR, RIVERS, THERMAL RADIATION TO SPACE |

its leaves and produce complex molecules of hydrocarbons which it stores in its root. Man cannot do this. He must eat the turnip to make the energy of sunlight available to him.

Man has of course discovered the sources of stored sunlight around him. He drives his cars on gasoline which is refined from crude oil, which represents stored sunlight from two hundred million years ago. He runs his hydro generators off water power, or stored sunlight in the form of spring rains held in gravitational reservoirs. However, in all of these endeavours, man is still brutally robbing his ecosystem. He is no more civilized than his ancestral ape. His steam shovel looks more complicated than a wooden club, but it is used to assault his environment in exactly the same manner. It is after all, a foolish assumption that after a million years of evolution, man has become civilized in the last thousand. Civilized man will not steal available energy from his native ecosystem, nor dump used energy as effluent upon his defenceless cousins. Civilized man will become completely detached from his native primordial earth. Education in the civilized society will promote a technology which utilizes forms of thermo-nuclear and gravitational energy directly to produce neg-entropic structures such as protein molecules for food energy, stored packages of gravitational energy for transportation, and physical complexes for extra-terrestrial housing.

Man's needs can be reduced to three basic entities - the availability of a source of energy, the availability of biological or mechanical devices for tapping off some of the energy flow from the source, and the availability of a heat sink or garbage dump to get rid of used energy. If any one of these three components is missing, life cannot be sustained. The rest of man's needs are derivatives from these, and if we consider man's needs to form a hierarchy, then these three will be at the apex.

Education must therefore lead man forth to new sources of available energy. It must enable men to seek new mechanisms for tapping the new sources. And finally, education must help men get rid of wastes and pollutants from their immediate environment. Thus the primary form of education is scientific research. All other forms, such as transfer of knowledge to succeeding generations, are secondary.

## LEVELS OF EDUCATION

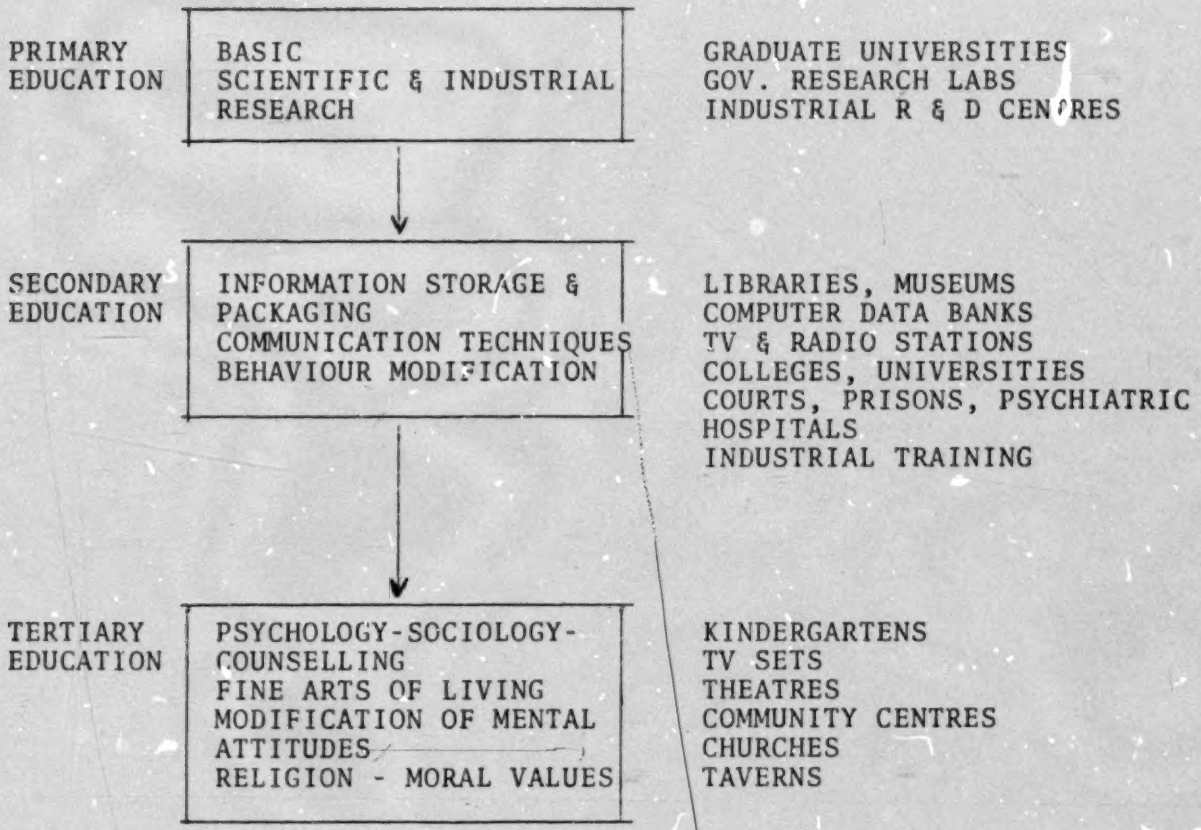



Fig. 1

## THE SYSTEMS APPROACH TO EDUCATION

In 1970 the Trotter report to the Committee of Presidents of the Universities of Ontario[1], pointed out that educational technology had not been effectively used in the universities. He attributed this misuse to a lack of administrative direction which had resulted in the compartmentalized thinking that considered education technology quite separate from other instructional ingredients such as teachers, students, the library and laboratories.

Trotter recommended... "a much more systematic approach to the problems of curriculum and course development. Objectives must be defined, all possible methods must be canvassed and evaluated, ... and then courses must be designed and evaluated every step of the way."[2]

The systems approach has been in vogue in educational literature for several years now. Yet there is no apparent attempt to tie it in with the much broader General Systems Theory. The General Systems Theory is an attempt at recognizing similarities in laws relating to various disciplines such as physics, biology, sociology, education etc. Since there is a limit to the number of parameters of a given system that can be included in the span of comprehension of a human mind, there is a very real need for formulating models and constructing paradigms to help conceptualize an otherwise chaoti reality. The General Systems Theory can be thought of as a paradigm of paradigms.

Watzlawick points out that there is theoretically no reason why the human mind cannot go beyond three levels of abstraction from the 'reality' of human sensory experience. Thus in order to gain insight into third-order premises man can do so only from a fourth level. In practice however, it is difficult to grasp meanings at this level. For example: "This is how I see you/ seeing me/ seeing you/ seeing me."[3] Any comprehension at higher levels is possible only by using mental crutches such as MODELS, MATHEMATICAL SYMBOLISM or PARADIGMS. (Einstein's concept of the gravitational field is depicted by a tensor of class 248!)

Korzybski illustrates how gains in comprehension of higher orders occur. "Einstein's structural discovery of the dependence of space and time... (causes) ... three-dimensional kinematics (to) become four-dimensional geometry, three-dimensional dynamics can be considered as four-dimensional statics. We see immediately the human, psychological, semantic

1. Trotter,B. Television & technology in University teaching.p 5
2. Ibid. p 51
3. Watzlawick et al. Pragmatics of human communication. p 266

## MAP OF LEVELS OF SYSTEMS EDUCATION[1]

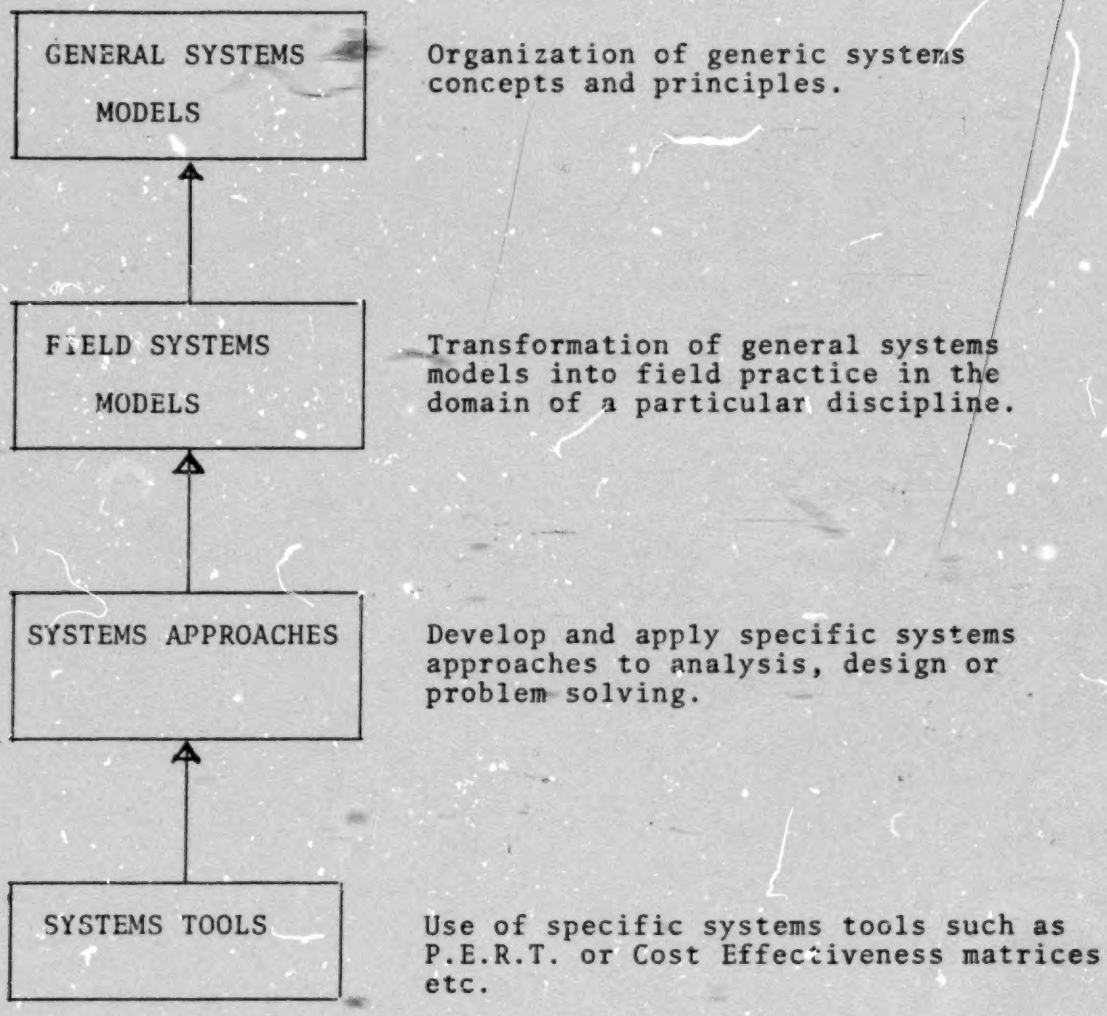

GENERAL SYSTEMS MODELS
Organization of generic systems concepts and principles.
FIELD SYSTEMS MODELS
Transformation of general systems models into field practice in the domain of a particular discipline.
SYSTEMS APPROACHES
Develop and apply specific systems approaches to analysis, design or problem solving.
SYSTEMS TOOLS
Use of specific systems tools such as P.E.R.T. or Cost Effectiveness matrices etc.

Fig. 2

1. B.H. Banathy. A systems approach of systems education, in Educational Technology. Feb. 1972. Vol. XII. #2. p 73.

importance of this fact. Our nervous sytem by its structure produces abstractions of different orders. The problems of sanity.., become problems of translation from one level to another, for which the structural advances in science supply us with methods of solution."[1]

Ultimately however, nothing inside a frame of reference can state anything about that frame. To ask questions about the boundaries of the frame, one must become an observer from an outside vantage point. This is why an educator cannot speak about the entire educational system. Wittgenstein once stated: "Whereof one cannot speak, thereof one must be silent." Thus, there are good theoretical reasons why educators who wish to speak about the educational system must cross the boundaries of their own subsystem and attain the vantage point of a General Systems Theory.

## EDUCATIONAL SYSTEMS & GENERAL SYSTEMS THEORY

Not only is there a theoretical reason for looking at overall educational systems from within the extended boundaries of General Systems Theory, but numerous practical concerns have recently become evident. Any system at all, regardless how inefficient or wasteful, can be made to work if sufficient energy throughput is maintained.

Therefore, in order to make a success of an educational system all that is necessary is to provide sufficient funds. Basically, most educational systems are in the business of building structures - both mental and physical. A simple increase in money input should result in an increase in structuring.

Recently, funding has been restricted. Therefore, if the same output is to be maintained, the system must become more efficient internally. Unfortunately, this is emphatically not a perfect solution. To illustrate the problems of dealing with adjustments only within the educational system boundaries, a few examples are necessary. First, let us assume that the educational system is told that its energizing input will be coupled via a positive feedback loop to the quantity of students entering the system boundary. The only response that the system could possibly make, is to open up the boundary to allow all possible entrants, qualified to enter or not.

1. Korzybski. p 647

Another example of limited perspective is the inability of educational institutions to even specify such relatively simple things as the costs of specific programs of study. Beyond the measure of internal costs lies an almost virgin wilderness of unexamined non-pecuniary costs and societal benefits of education.

Certainly the boundaries of education must not cease at the university or college gates. There is an urgent need for accurate information on exactly how the education a student received is utilized after graduation.

It clearly shows the need for a broader systems approach when educational institutions are forced to analyze the Cost/Benefit of education in terms of Cost/Degree ratios. The cost (energy input to the system) is easily measurable, as is the system output in terms of quantity of degrees granted. However, the ultimate tendency for a closed system which has its performance measured in the number of degrees granted, is to maximize the number of degrees. When this second tendency is coupled to the first, our universities will soon be accepting idiots and grinding out degrees by the thousand in their print shops. This process is guaranteed to proceed until the outraged taxpapers (negative feedback) demand a stop. Thus, with the ever-increasing political pressure for more effective education and with limited funds, there will come a time very shortly, when Cost/Benefit ratios given in terms of Cost/Degree will no longer be acceptable. What is needed is a wider system with boundaries which encompass all the societal and political structures external to the school environment. This then constitutes a very practical reason for adopting a new paradigm of the educational system.

## ADOPTION OF A NEW PARADIGM

Hegel's dialectic method consists of a continuous revolution from one state of knowledge to another. The process consists of an original thesis which is at some later stage followed by an antithesis and finally a reconciliation of theis and antithesis into a synthesis. This new synthesis retains the elements of the original thesis plus it contains the elements of knowledge in the antithesis. Both sets of elements are however now seen to be in harmony from the new higher level of knowledge attained by the synthesis.

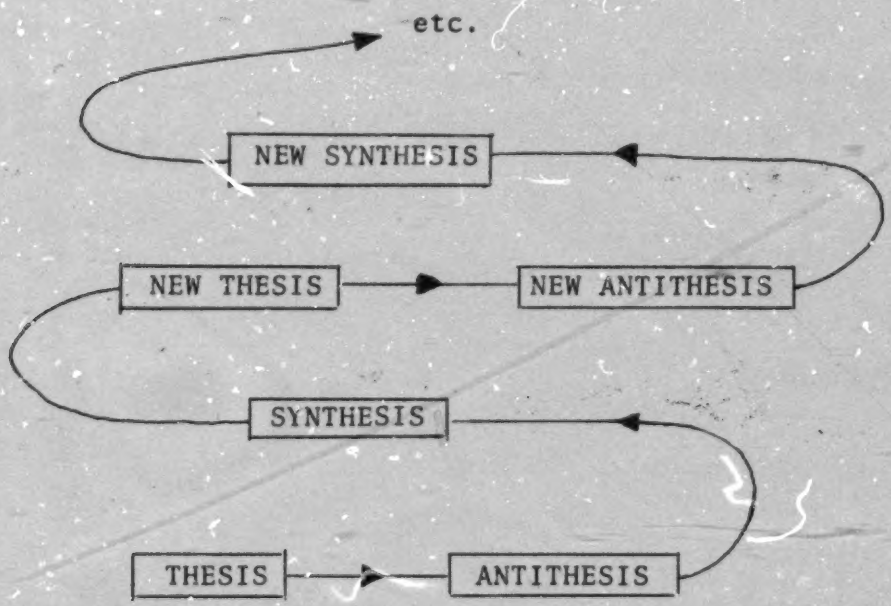
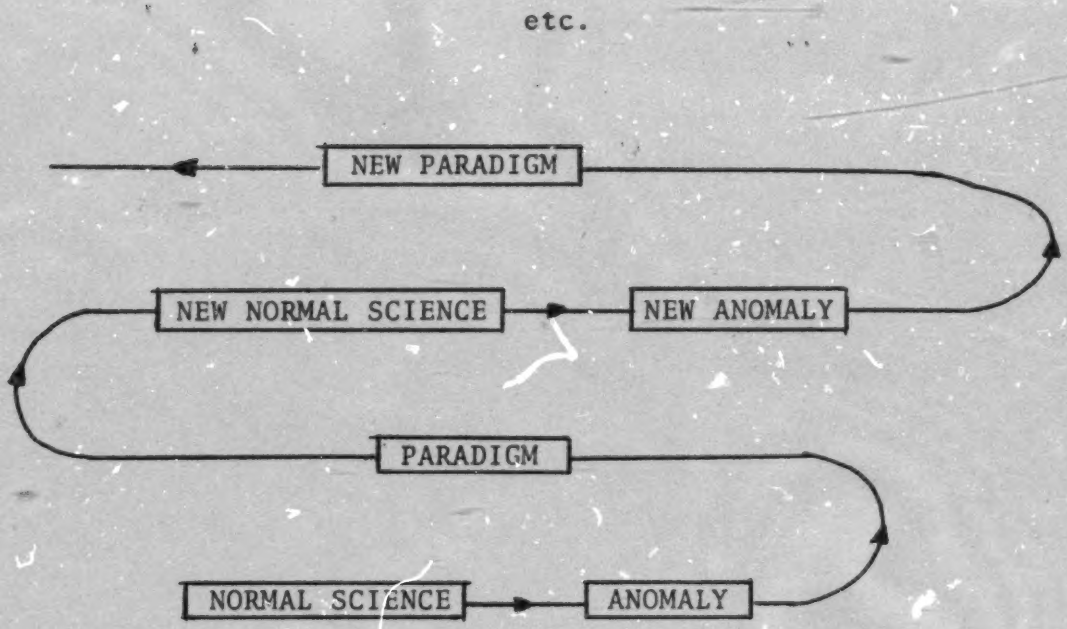



Fig.3 HEGEL'S DIALECTIC SPIRAL OF INCREASING LEVELS OF KNOWLEDGE OR DECREASING LEVELS OF ENTROPY

Kuhn's theory for the structure of scientific revolutions maintains that whenever an anomaly appears in the course of 'normal' traditional science, a new way of conceptualizing the world will be born. This new paradigm will eventually assume the role of a new 'normal' science. The similarity here to Hegel's dialectic is readily apparent.




KUHN'S STRUCTURE OF SCIENTIFIC REVOLUTIONS

Fig. 4

Various paradigms similar to Kuhn's system have been proposed for educational systems. Most of these proposed systems are spiral or cyclical in nature. For example a typical procedure for curriculum development is as follows:

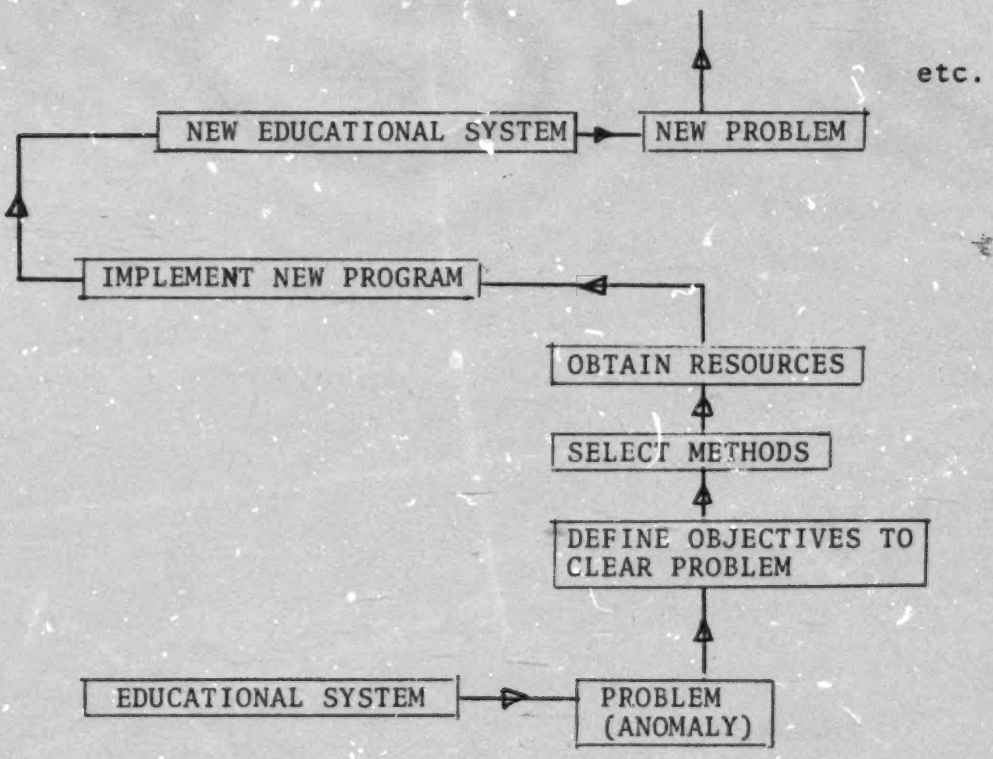
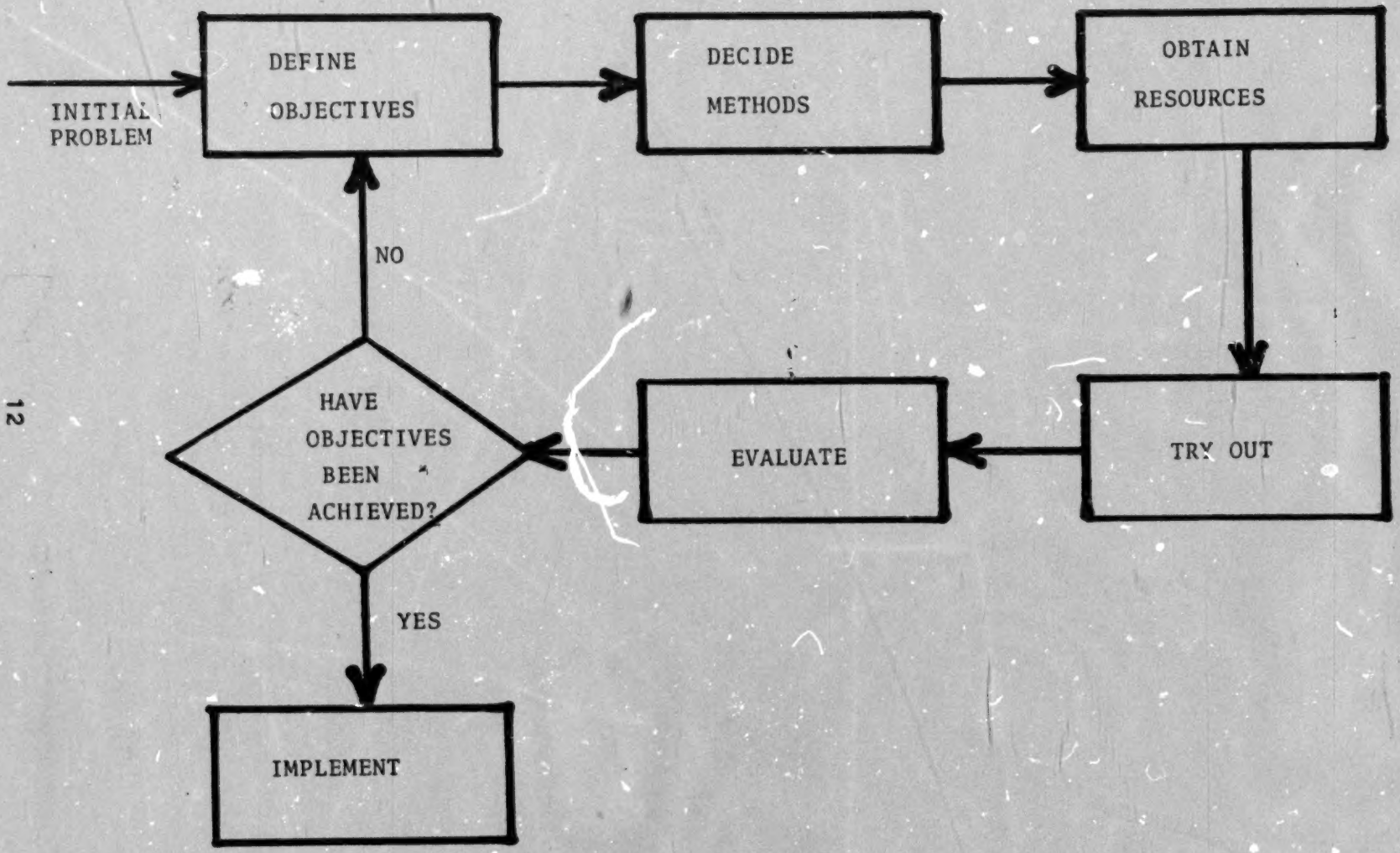



Fig. 5




CYCLICAL DEVELOPMENT OF CURRICULUM

fig. 6

A more detailed description is given by Banathy.[1]

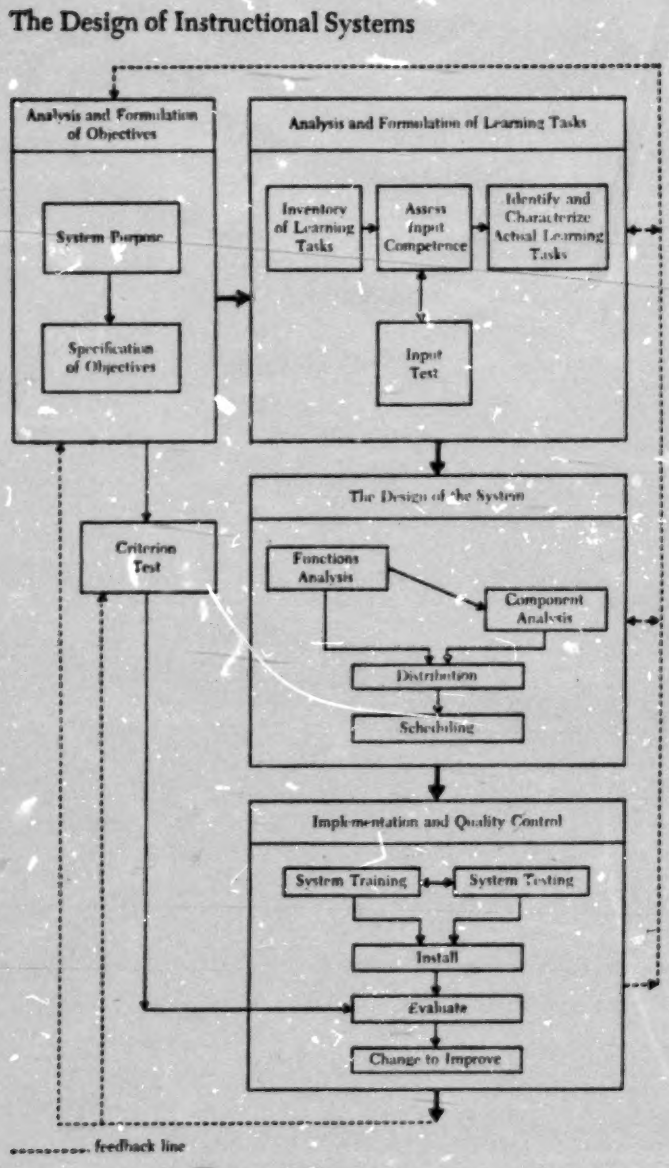



fig.7.

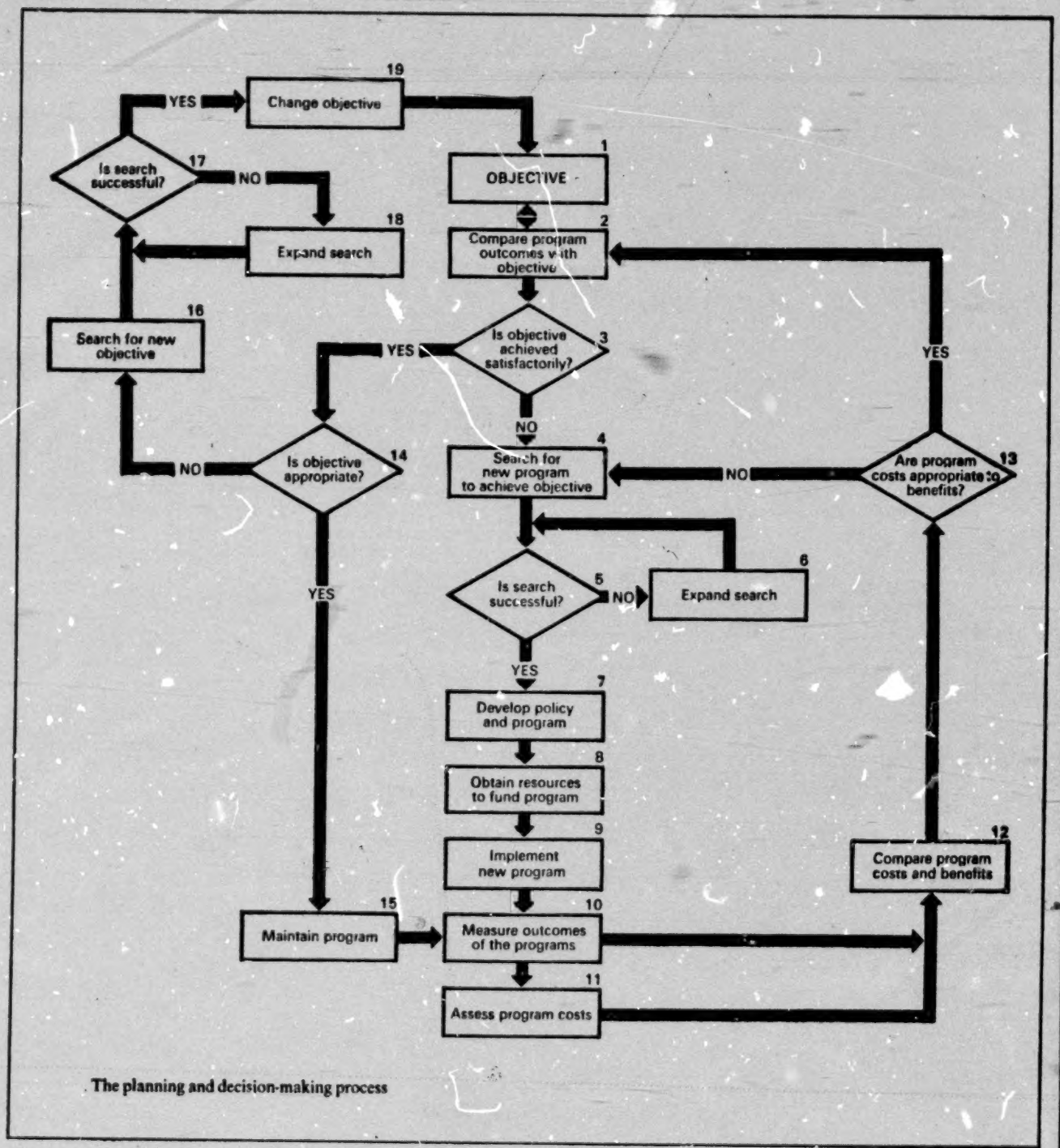
1. Banathy, p 83.

Banathy lists the major system strategies as follows:[1]

1. Formulate specific learning objectives.
2. Develop tests to measure the degree to which objectives have been attained.
3. Examine the input characteristics of the learners.
4. Identify whatever has to be learned so that the learner will perform as expected.
5. Consider alternatives and resources.
6. Install the system and evaluate it.
7. Regulate the system. (Feedback from testing)

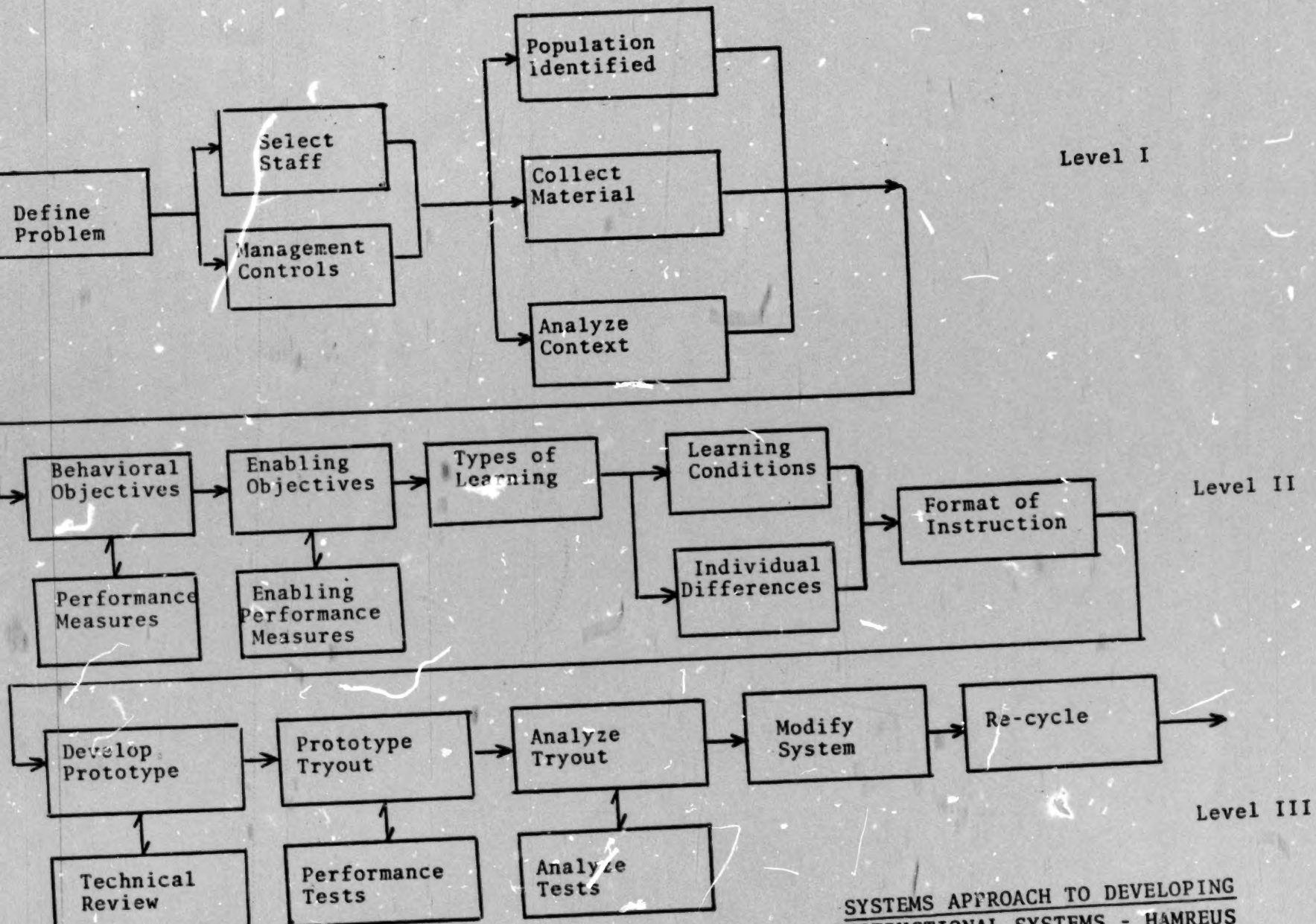
Another model for program planning is proposed by Greenfield et al., OISE, 1968. (See fig.8.)

1. Banathy. p 22.




The planning and decision-making process

fig. 8




SYSTEMS APPROACH TO DEVELOPING INSTRUCTIONAL SYSTEMS - HAMREUS

fig.9

Hamreus sees three main levels in the systems approach to instructional development.[1] (see fig.9.)

1. Systems Definition and Management Stage.
2. Design Analysis Stage.
3. Development and Assessment Stage.

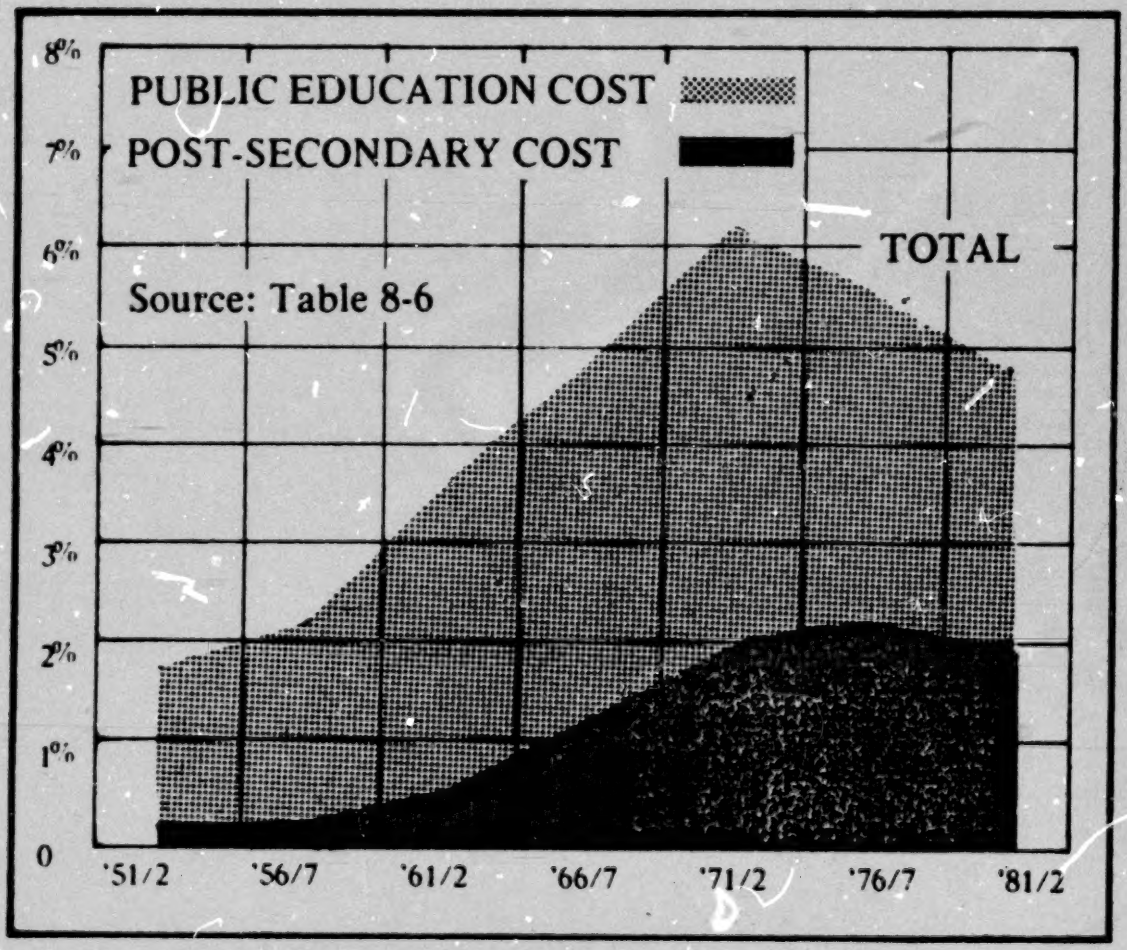
In any case, a cursory glance at the complexity will immediately reveal the high probability of errors. Consequently a common feature of all systems is their cyclical nature. Following the ASSESSMENT stage there will eventually be a return to SYSTEMS RE-DEFINITION. This return is triggered by the appearance of some anomaly in the system such that the system cannot meet its original criterion tests. Note the similarity here to Kuhn's "Structure of scientific revolutions" where he maintains that the presence of an anomaly necessitates a new paradigm which then 'explains' normal scientific procedure until the occurrence of a new anomaly. The idea is not new because it is in essence Hegel's helical concept of THESIS → ANTITHESIS → SYNTHESIS. Each new synthesis resulted from the incorporation of all previous 'knowledge' with the new knowledge caused by an anomaly in the old concept. Each cycle produced a new level of understanding (lower entropy), hence the helical or spiral concept.

1. Hamreus, p. I - 20

EXAMPLES OF ANOMALIES

The existing educational system has recently been criticized. What then is the nature of the latest anomaly? Some people believe that the cost of education is increasing too rapidly and it is feared that some other societal needs will be prejudiced.[1]

## Cost of Education
## As a Percentage of Gross Provincial Product




1. The learning society - Report of the Commission on post-secondary education in Ontario, Ministry of Government Services, Toronto, 1972. p.162

The question of costs implies two things. First, the total cost expressed as a percentage of the gross Provincial Product may be too large. Second, the amounts spent are not buying satisfactory services either in terms of quantity or quality.

The presently used paradigms or systems models for curriculum development all have one feature in common. None of them are concerned with the cost/benefit of education. Whereas many are systems models, the systems are too limited. Their boundaries do not include any evaluation of the 'real' societal benefits of education. One cost/benefit analysis was undertaken of the Post-Secondary Institutions in Ontario by the Systems Research Group. This study was a background paper to the Report of the Commission on Post-Secondary Education in Ontario.[1]

However, the final report simply states that: "The cost-benefit approach to education also is unsatisfactory." [2]

The S.R.G. study apparently could not come to grips with the problem because of the lack of data to enable a rational systematic analysis. Most institutions have difficulty in even stating the number of enrolled students. The records of costs per individual program are usually non-existent - sometimes deliberately so. Thus the measurement of costs is difficult. The price to be attached to the output of educational institutions in terms of societal value is impossible to measure. It is thus truly priceless.

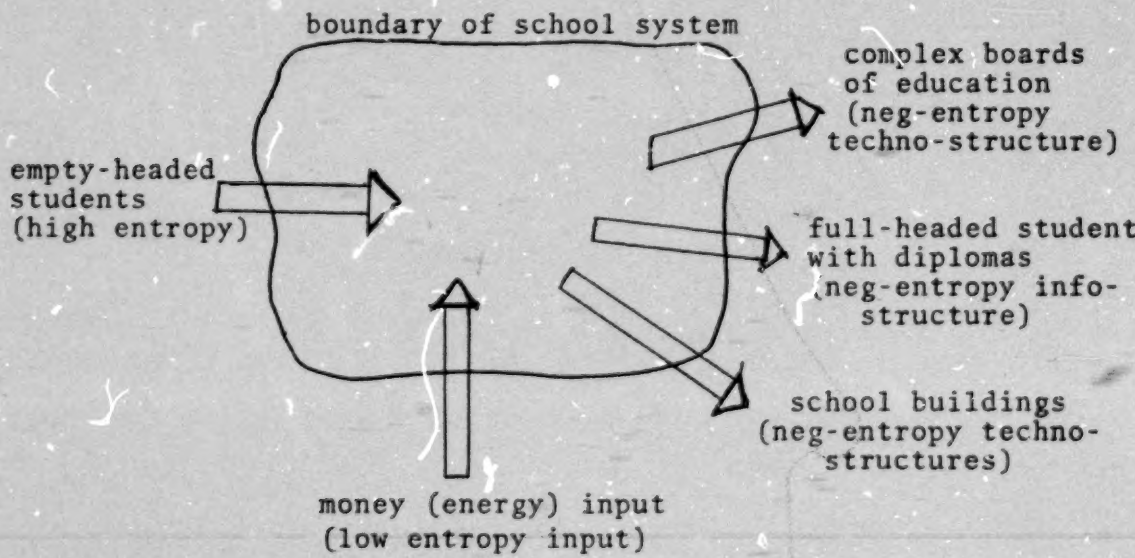
1. S.R.G. Cost and benefit study of Post-Secondary Education in Ontario in 1968-69. Queen's Printer, Toronto, 1972.

2. The learning society, p.31.

The new educational paradigm must incorporate structures which will remove present anomalies. It must consider new methods of measuring the societal benefits of 'education'. These new measurements must not only be given in terms of money (or energy markers), but also in terms of other life values (neg-entropic structures). It is assumed here that a dollar bill has little inherent neg-entropic value. (For example it would generate only a very small amount of available energy if it were burnt as fuel.) Rather, its value rests on the fact that it is a symbol for large amounts of available energy, or it is an 'energy marker'. (For example, the same dollar bill will buy 1/3 bag of coal or 33 pounds of high energy fuel.)

Similarly,,the neg-entropic value of a graduation degree from a College, is hopefully much larger than the amount of BTU's contained in the paper it is printed upon. The degree is a symbol for the education (neg-entropic mental structures) imprinted in the student. These mental structures (info-structures) should enable the individual to help optimize his energy utilization or to open up new sources of available energy. Thus the degree is a symbol - a marker for enhancement of personal and/or societal energy flows.

Finally, the new paradigm must incorporate both mechanisms for the education of individual man as well as Man the species. This need arises from the anomaly generated by the advent of genetic engineering. Genetic engineering can 'educate' the genetic infostructure of the race, not merely raise the complexity of individual mental structures as did the old educational system.


boundary of school system
complex boards of education (neg-entropy techno-structure)
empty-headed students (high entropy)
full-headed students with diplomas (neg-entropy info-structure)
school buildings (neg-entropy techno-structures)
money (energy) input (low entropy input)

## THE COST-BENEFIT MODEL

The cost/benefit ratio is basically a ratio comparing two quantities of energy.

First, there is the cost(dollars) (energy markers) needed to 'educate' a person. Second, there is a benefit derived from the education. This should also be obtained in terms of energy markers.

$$\frac{\text{Cost}}{\text{Benefit}} = \frac{x \text{ dollars}}{y \text{ dollars}} = \frac{x_1 \text{ energy markers}}{y_2 \text{ energy markers}} = \frac{x_1 \text{ energy}}{y_2 \text{ energy}}$$

Generally, the difficulty lies in the fact that whereas the cost is available in terms of dollars, the benefits in terms of the energy made available are difficult to measure.

Ultimately, the potential available work from any given form of the energy needs to be measured. It will be shown later that this measure is related to a new concept called ESSERGY. As far as education is concerned, (or any of the information sciences), this concept is related to the idea of $\frac{\text{SIGNAL}}{\text{NOISE}}$ ratios.

Thus the ultimate analysis of education will separate the energetics of educational systems into three categories:

a) Work input (to establish and maintain the system)
b) Noise
c) Signal (information transfer)

The WORK INPUT component includes all energy expenditures to build the school, feed the students, transport teachers and students, heat the buildings, print the textbooks, transmit information, etc.

The NOISE component includes all the entertainment (consumption) irrelevant courses, student failures, redundant information, waste heat generated by inefficient information transfer mechanisms, etc.

The SIGNAL component includes those bits of non-redundant information which will be used by the graduates to enhance energy flow in their society.

The Benefit/Cost ratio is thus related to the Signal/Noise ratio

To further compound the problem of measuring benefits, it is necessary to consider at least some components of education as 'conspicuous consumption'. Entire programs or courses may be undertaken for no apparent economic motive. How a course such as witchcraft can help in an economic sense is difficult to explain - unless of course, alchemy was also on the agenda. Such courses have an obvious entertainment value. However, even in a course such as 'machine design', the Friday afternoon film on the Apollo 11 spaceshot requires some rationalization.

In any case the word 'economics' is itself not properly used. The Greek word 'oikonomia' means: 'oikos' - house, and 'nomos' - law or rule. Hence economics is really the regulation or government of a household. Whereas this concept was applicable to the small Greek city-state, its application to large nations of many millions, operated upon by the powerful forces of multinational corporations and the mass media etc. is misleading. For studies dealing with sociology, energy utilization patterns, education, communications networks, industrial and human capital, the word 'economics' must be replaced by SOCIONOMICS. Thus an 'economic' analysis of education would certainly be too simplistic, whereas a socionomic analysis of Cost/Benefit ratios, even though infinitely more difficult, should prove significant.

Human capital theory[1] states that the knowledge gained by individuals through learning, resides in the learner as embodied capital. This knowledge or embodied capital is claimed to have a direct effect on the productivity of labour. However, because this type of capital may never be used, or not used to best advantage, the pecuniary benefits of higher education may not always be realized. In 1965 the Economic Council of Canada estimated that the rate of return on human investment was from 15 to 20%. However, the higher costs of education in the 70's coupled with a more difficult job market should yield substantially smaller benefits.

The SRG study broke the costs into two categories. First; the student costs included such things as fees, books, equipment, living costs and opportunity costs such as the cost of foregone earnings while remaining in school. Second; the social costs which include all costs to society, such as institutional opportunity costs as well as individual costs. Included are also, student awards, salaries and operating expenses, expenditures due to depreciation, debt payments, government operating grants, student aid programs, capital grants, and rebates of sales taxes.

1. SRG - Cost Benefit Study, p.9.

ALLOCATION OF RESOURCES IN THE POST-SECONDARY EDUCATION SYSTEM

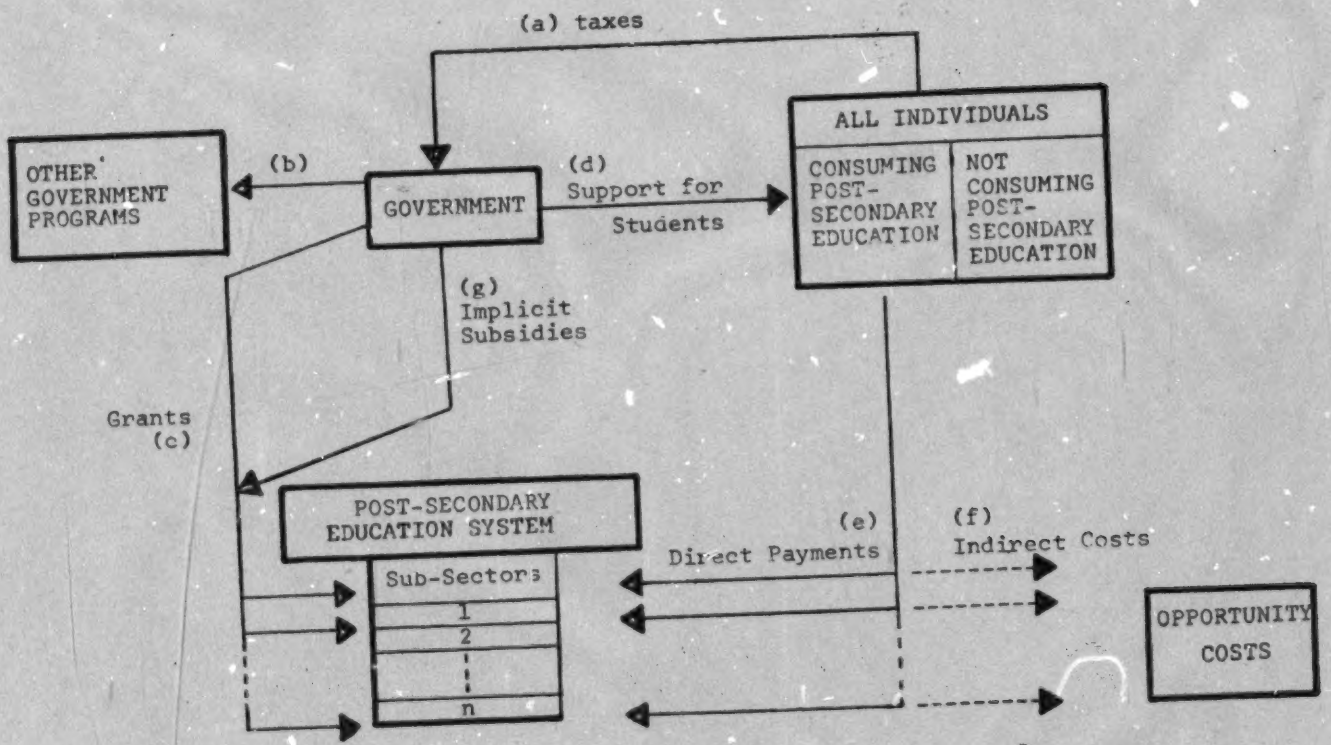



fig. 10

The SRG group use the example of an education in engineering. The value of the human capital resulting from an investment in an engineering degree can be estimated by computing the net present value of the differential earnings between a sample of graduate engineers and a control sample of high school graduates of similar inherent ability. [1]

Unfortunately the solution is not that simple. One factor which was already mentioned is that an education is merely a mental map of how to improve the wealth of the economy. If the life situation is such that a person is prevented by other socio-nomic forces from making use of his education, then obviously the education is of little monetary worth. Examples of this are all around us. Often, women have been quietly discriminated against. Similarly a person without an Anglo-Saxon background often needs twice the education of a comparable native. The value of return on their education for certain classes of people is thus considerably discounted.

Another factor is that Canadian university education is generally regressive in nature as an income redistribution mechanism. The SRG study[2] showed that students whose families earn between $3,000 and $4,000, and $4,000 to $7,000 receive less benefits than their contribution to the costs of education while students whose families earn more than $7,000 receive a proportionately greater amount. Thus our universities do not give education to those who can best benefit by it. This constitutes a vast waste of human capital---a luxury which only an elitist society can afford. (See fig. 11 )

A third complicating factor is the reliance of Canadian industry upon the research and development of the North American industrial infostructure. Most of Canadian resource and heavy manufacturing industry operates as subsidiaries of U.S. parent companies. Thus there is access to new technology. The beneficial aspects of this relationship must be weighed against the adverse side effects. One such effect of a net import of infostructure in exchange for raw resources and energy, is that bright young educated Canadians cannot find challenging positions in Canada.

1. S.R.G. Cost Benefit Study. p9
2. Ibid. p 81

fig. 11

UNIVERSITIES

AGGREGATE REDISTRIBUTIVE ANALYSIS

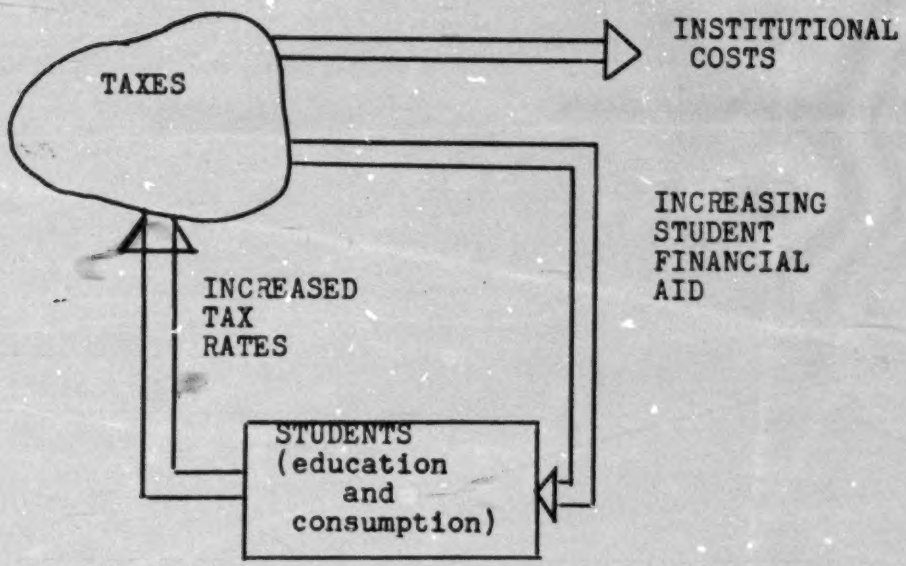
COSTS

| COMPONENT | UNDER $3,000 | $3,000 - $4,999 | $5,000 - $6,999 | $7,000 - $9,999 | $10,000 + |
|---|---|---|---|---|---|
| (1) FEDERAL | 7.68 | 18.32 | 25.58 | 21.82 | 26.60 |
| (2) PROVINCIAL | 10.39 | 20.00 | 25.53 | 20.60 | 23.48 |
| (3) REST OF ECONOMY | 5.00 | 8.00 | 10.00 | 25.00 | 52.00 |
| (4) STUDENT | 8.53 | 11.96 | 18.15 | 24.59 | 36.77 |
| (1 + 2 + 3 + 4) SOCIETAL | 9.09 | 16.74 | 22.76 | 22.26 | 29.15 |

BENEFITS

| | UNDER $3,000 | $3,000 - $4,999 | $5,000 - $6,999 | $7,000 - $9,999 | $10,000 + |
|---|---|---|---|---|---|
| STUDENT | 9.36 | 12.35 | 18.25 | 24.41 | 35.63 |

A fourth factor involves the observed fact that there is an inherent bias on the part of individuals to under-invest in human capital.[1] Thus it is unlikely that students will pay the full cost of their own education. Consequently there are many different inducements presently lavished upon students to get them to enroll at a university. There are student financial aid awards, bursaries, interest-free loans, scholarships etc. All these are in addition to the societal cost of maintaining the institutions and paying the salaries of the faculty. Related to this problem is the effect of a sliding tax rate structure. The more a graduate earns, the more tax he pays. Let us suppose that the tax is such that EVERYONE finally earns exactly the same take-home pay. Now there is still an obvious societal benefit from education, but there is zero individual monetary return. At this point the government will undoubtedly have to pay the entire cost of education as well as paying the student equivalent opportunity costs.




1. S.R.G. Cost Benefit Study, p 9

fig. 12

UNIVERSITY - UNDERGRADUATE

STUDENT AND SOCIETAL COSTS BY PROGRAM

| PROGRAM NAME | STUDENT COST | SOCIETAL COST | % SOCIETAL COST BORNE BY STUDENT |
|---|---|---|---|
| Agriculture | 9,083 | 33,820 | 26.85 |
| Architecture | 13,495 | 44,518 | 30.31 |
| Commerce | 9,084 | 28,021 | 32.41 |
| Dentistry | 13,353 | 53,238 | 25.08 |
| Engineering | 9,435 | 34,175 | 27.60 |
| Fine & Applied Arts | 9,097 | 28,[illegible] | 32.04 |
| Forestry | 9,268 | 33,965 | 27.28 |
| Household & Food Science | 9,112 | 33,807 | 26.95 |
| Journalism | 9,151 | 22,248 | 41.13 |
| Law | 12,230 | 35,982 | 33.98 |
| Library Science | 9,095 | 23,655 | 38.44 |
| Pre-Medicine & Medicine | 16,433 | 59,977 | 27.39 |
| Music | 8,964 | 33,873 | 26.46 |
| Nursing | 9,577 | 34,272 | 27.94 |
| Pharmacy | 8,540 | 33,230 | 25.69 |
| Physical & Health Ed. | 9,160 | 28,086 | 32.61 |
| Phys. & Occ Therapy | 6,532 | 19,318 | 33.81 |
| Social Work | 6,592 | 16,385 | 40.23 |
| Veterinary Medicine | 9,214 | 45,508 | 20.24 |
| Theology | 6,269 | 16,060 | 39.03 |
| Hon Gen.Art 1/Geography | 6,575 | 16,382 | 40.13 |
| Hon Art Upper/Humanities | 8,618 | 26,580 | 32.42 |
| Hon Gen.Sci/Phys-Biol. | 6,336 | 16,405 | 38.62 |
| Upper Yrs. Hon Sci/Math | 9,974 | 35,211 | 28.32 |
| Secretarial/Child Study | 6,631 | 16,425 | 40.37 |
| Landscape Arc/Psychology | 8,365 | 34,881 | 23.98 |
| Dip.Public Ad/Res.Soc.Sci. | 1,078 | 5,019 | 21.47 |
| Dip. General Arts | 1,892 | 5,123 | 36.93 |
| Diploma Commerce | 1,890 | 5,121 | 36.90 |
| Diploma Music | 1,903 | 8,034 | 23.68 |
| Diploma Nursing | 2,003 | 5,234 | 38.26 |
| Dip.Phys.Oc.Therapy | 1,906 | 6,587 | 28.93 |
| Dip.General Sci. | 1,900 | 5,131 | 37.02 |
| Dip. Nursing Tech. | 1,596 | 4,824 | 33.08 |
| Dip. Dental Hygiene | 1,815 | 7,945 | 23.85 |
| Dip. Public Health Nursing | 1,889 | 8,019 | 23.55 |
| Dip. Technology Course | 1,594 | 4,822 | 33.05 |
| Dip. Preliminary Year | 1,890 | 4,251 | 44.46 |
| Dip. Med.Intern-Residents | 1,22[illegible] | 5,976 | 20.44 |

A summary of the SRG cost analysis is shown in Fig.12. This table illustrates the different percentages of societal cost borne by students enrolled in various programs.

Next, a Benefit Cost Ratio was computed in accordance with the following formula, for any given program k. [1]

$$\frac{\text{BENEFIT}}{\text{COST}} = \sum_{j=1}^{M} \frac{Z_{jk}}{(1+r)^{j-1}} \Big/ SC_k$$

k= any given post-secondary program
SC= student costs
j = a year variable
$Z_{jk}$ = expected earnings by year j given graduation from program k
M = final working year after graduation
r = discount rate

It was pointed out however, that the following variables could modify the expected earnings.

a) Taxation rates
b) Labour force participation
c) Real economic growth in per capita income
d) Mortality
e) Inherent ability of the student
f) Consumption benefits of the education
g) Migration of graduates
h) Discount rate on the education received.

A tabulation of the results is shown in Fig. 13

1. SRG Cost Benefit Study p 36
2. Ibid. p93

## ANALYSIS OF RETURNS BY PROGRAM

### Males, Selected Occupations

| OCCUPATION | PRIVATE | | | SOCIETAL | | |
|---|---|---|---|---|---|---|
| | RATE OF RETURN | NET PRESENT VALUE | BENEFIT COST RATIO | RATE OF RETURN | NET PRESENT VALUE | BENEFIT COST RATIO |
| Dentistry | 56.50 | 95,348 | 8.14 | 19.59 | 103,646 | 2.95 |
| Vet. Medicine | 36.57 | 35,291 | 4.83 | 9.84 | 16,731 | 1.37 |
| Social Work | 30.53 | 8,455 | 2.28 | 9.73 | 3,346 | 1.20 |
| Agriculture | 27.55 | 17,938 | 2.97 | 8.03 | 2,047 | 1.06 |
| Medicine | 25.45 | 75,551 | 5.60 | 13.11 | 81,020 | 2.35 |
| Pharmacy | 24.73 | 25,492 | 3.99 | 9.96 | 15,137 | 1.46 |
| Law | 20.60 | 45,789 | 4.74 | 12.74 | 49,417 | 2.37 |
| Library Science | 14.08 | 11,364 | 2.25 | 8.52 | 5,183 | 1.22 |
| Commerce | 14.04 | 11,855 | 2.31 | 7.75 | 1,833 | 1.07 |
| Forestry | 14.00 | 11,829 | 2.28 | 6.71 | -3,966 | 0.88 |
| Architecture | 13.65 | 16,769 | 2.24 | 8.03 | 2,047 | 1.06 |
| Engineering | 13.59 | 11,307 | 2.20 | 6.56 | -4,732 | 0.86 |
| Journalism | 11.52 | 7,625 | 1.83 | 7.71 | 1,449 | 1.07 |
| Physical Occ. Therapy | 0.74 | -5,717 | 0.12 | * | -17,711 | 0.08 |
| Nursing | * | -13,157 | -0.37 | * | -58,215 | -2.62 |
| Theology | * | -39,055 | -5.23 | * | -38,986 | -0.14 |

Assumptions:

Discount Rate - 7%
Ability Factor - 0.2
Growth Rate - 2.7%
Transitions - Neutral

Fig. 13

Cost-Benefit analysis must not be viewed as an ultimate, deterministic solution to educational anomalies. As BANATHY has pointed out, there is no single best solution given by cost-benefit analysis, but rather a continuum with unacceptably high costs at one end, and unacceptable levels of effectiveness or benefits at the other.[1]

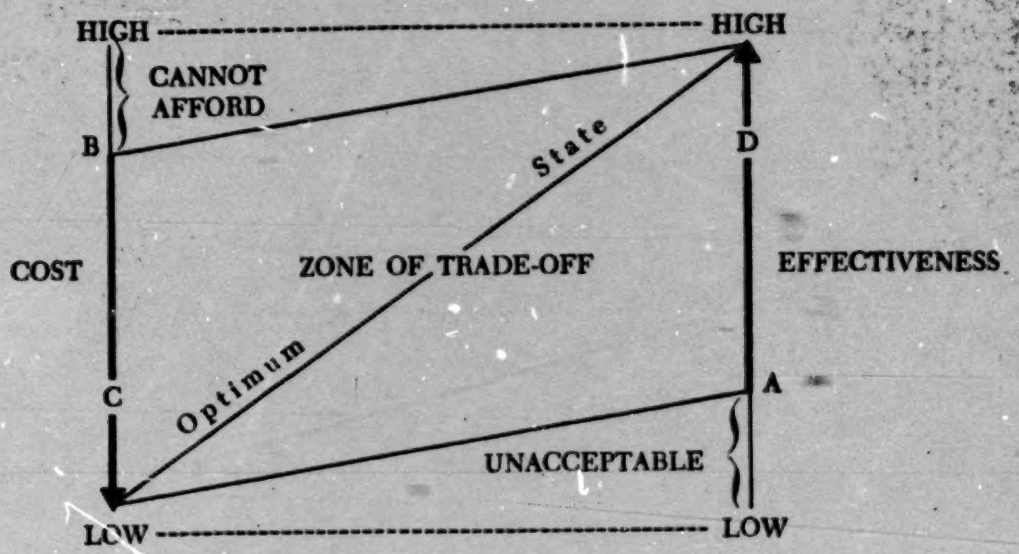



fig. 14

In fact, the Wright Commission has rejected the Cost-Benefit approach altogether.[2] Instead, they suggest a 'social demand' basis for education.[3] This is supposed to be in keeping with presently held values in our society. However, since the supply-demand type of economic philosophy is being increasingly questioned, it is doubtful if 'social demand' will answer our questions about the future of education.

1. Banathy, B.H. Instructional systems. p.73.
2. The learning society. p.31.
3. Kirkaldy and Black, Social reporting and Educational planning Commission on Post-secondary Education in Ontario. Queens Printer. 1972.

## WHAT IS ENERGY

The word energy comes from the Greek 'ergon' or work. Energy is the capacity for producing an effect, it is the power to do work. Energy may be manifest in a variety of forms: mechanical, electrical, thermal, chemical, atomic, etc.

In the universe two classes of energy are apparent. One is stored energy, the other is transient. The stored energy is found in such forms as: gravitation, rotation, and orbital motion. Of these, the gravitational form is the predominant. The stored gravitational energy may be released by letting a mass fall inward upon itself and radiate light and heat in the process. Thus the evolution of the universe is a history of gravitational contraction.

For example, our sun is in the process of gravitational collapse. However, it must first burn up its supply of hydrogen (about another 5 billion years), before it can continue to shrink.[1]

Each time that the stored gravitational or rotational energy is altered to a transient form such as heat or light, the energy is degraded. The energy becomes less available to do work or becomes more 'polluted' or disordered. The degree of pollution of energy is known as entropy. Various forms of energy can be ordered in terms of increasing entropy.[2]

| | ENTROPY |
|---|---|
| GRAVITATIONAL | 0 |
| ROTATIONAL | 0 |
| ORBITAL MOTION | 0 |
| NUCLEAR REACTIONS | $10^{-6}$ |
| INTERNAL HEAT OF STARS | $10^{-3}$ |
| SUNLIGHT | 1 |
| CHEMICAL REACTIONS | $1 \rightarrow 10$ |
| WASTE HEAT | $10 \rightarrow 100$ |
| COSMIC MICROWAVE RADIATION | $10^{4}$ |

1. Dyson, Energy in the universe. Scientific American. Vol.224 #3, 1971. p.54.
2. Ibid. p.52.

## WHAT IS ENTROPY

There is a very basic easily observable fact which permeates our everyday life. Rivers always run downhill, fires always consume fuel, radio-active materials slowly disintegrate, our sun is gradually burning itself out. In fact within the boundaries of our sensory universe, all processes progress in one direction. There may be temporary stoppages and there may even be local reverses, but there appears to be one overall space-time characteristic which has been quantified and labelled as the Second Law of Thermodynamics. This law simply stated means that the main thrust of the visible universe is a shift in the direction of increased entropy or maximum disorder (thermal pollution). The total energy present may indeed remain constant, but it will be so evenly distributed that there will be no energy available to flow from one point to another. This is because all points will be at the same potenti and there will not be any potential gradients to cause flows. When all flows cease, time itself stops. This 'vast', dimensionle timeless cosmic tranquillity is the final repose for our galacti show of thermodynamic fireworks.

The final treatise on human history will be written in terms of thermo-dynamics. It will have little to do with national boundaries or with politicians and their armies. The basic thermodynamic flow is apparently one of the most fundamental laws perceptible to Man. It is not up to man to stop or reverse this river of God. The 'free-will' of man rests only upon his ability to tamper with the direction of local rates of flow. Human history will merely be a temporary record of these local conditions. Until finally even these neg-entropic records will vanish in the ultimate thermo-dynamic death of a max-entropy universe.

If the purpose of Man is to extinguish light, then the future of education is to hasten the night!

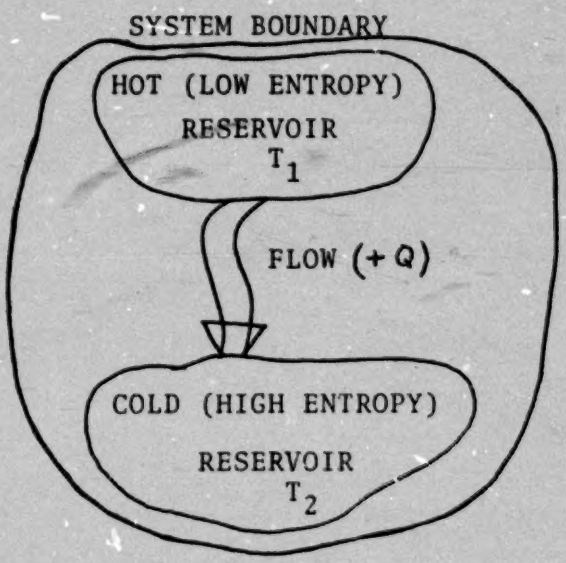
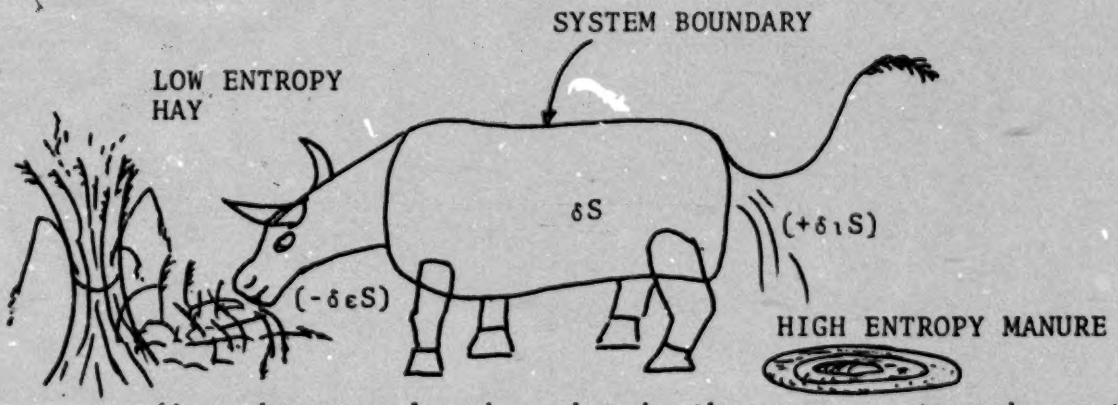



fig.15 CLOSED SYSTEM




(Assuming more hay is going in than excrement coming out, the net result is a negative δS or lowering of system entropy - hence the cow keeps growing.)

fig.16 OPEN SYSTEM

## THE SECOND LAW OF THERMODYNAMICS

In the closed system (no energy enters or leaves), there will be a heat flow (Q) from the HOT RESERVOIR to the COLD RESERVOIR.[1]

i.e. Heat supplied to cold reservoir = +Q
∴ Increase of entropy = $\frac{+Q}{T2}$

Heat supplied to hot reservoir = -Q
∴ Increase of entropy = $\frac{-Q}{T1}$

∴ Net increase of system entropy

$$\Delta s = \frac{Q}{T2} - \frac{Q}{T1}$$

Since T1 > T2, $\Delta s$ must be positive. This indicates that there will always be a net INCREASE in entropy. In the case that $\Delta s \rightarrow 0$, then the difference in temperatures between the reservoirs must have been minutely small.

Thus in general, for a closed system, entropy never decreases, or:

$$\delta S \geq 0$$

On the other hand all living systems must maintain themselves in a state of high order (low entropy), otherwise they would die and decompose. The living organism must be treated as an 'open system', where energy can be both imported and exported through its system boundaries. In this case the total change in entropy is:

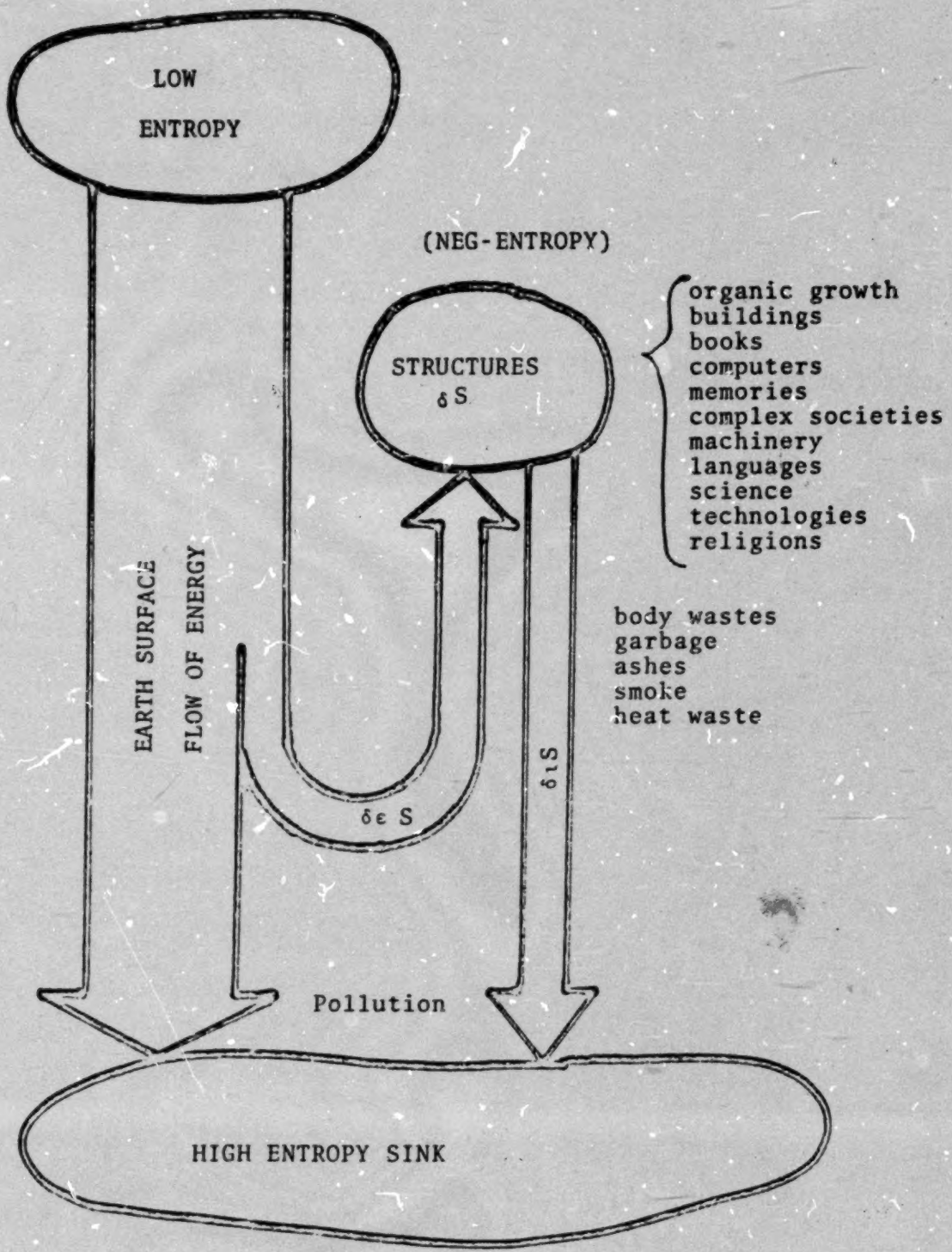
$$\delta S = \delta_e S + \delta_i S \quad 2$$

$\delta_e S$ = change in entropy by import
$\delta_i S$ = production of entropy by irreversible processes within the system((i.e. digestion of food)

The term $\delta_i S$ is always positive, but $\delta_e S$ can be negative as when the organism swallows food from outside its own body.

1. Eastop. p 136
2. Bertalanaffy. p 144

atomic energy and its derivatives
such as fossil fuels, sunlight,
hydro power etc.



## WHAT IS ESSERGY?

There may ultimately be theoretical reasons why Man may never know what energy 'really' is. Energy and information are different manifestations of the same sub-phenomenon - entropy. The measure for entropy in communications was formulated by Shannon as:[1]

$$S(Q/X) = -K\sum p_i \ln p_i$$

The information (I) contained in a message was then the difference between the uncertainty (entropy state) associated with the initial state of knowledge (X) before arrival of the message, and the state of 'certainty' ($X^1$) after arrival of the message. Thus:

$$I = S(Q/X) - S(Q/X^1)$$

The entropy used in classical thermodynamics was defined as the difference between two states X and $X^1$ when a conversion occurs between mechanical and thermal energy states.

$$S^1 - S = \int_X^{X^1} \frac{\delta Q_r}{T}$$

These two functions have been shown to be mathematically equivalent. Tribus[2] illustrates this point very simply. The concepts of "Distinguishable from the environment" as applied to information, and "Out of equilibrium" as applied to energy systems are identical. Thus thermodynamic information means the same as "Degree of departure from equilibrium."

Evans[3] in 1969 took the equation for entropy($S_0$) of any system when energy (E), volume (V) and chemical composition ($N_i$) are evenly distributed at a temperature $T_0$ and pressure $P_0$ and chemical potentials $\mu_{i_0}$

$$S_0 = \frac{E - P_0V - \sum \mu_{i_0} N_i}{T_0}$$

1. Tribus and McIrvine, Energy and information. Scientific American. Sept, 1971. Vol.224, #3. p180.
   (See also: Shannon and Weaver, The mathematical theory of communication. University of Illinois Press,1964. p50)
2. Ibid.
3. Ibid., p186.

Because of the even distribution, no one component can be 'recognized' from its background. If we want to 'observe' a system from its environment, we require information (I) such that $I = S_o - S$

(S is the uncertainty about the system formed with energy E, volume V, and composition $N_i$)

Thus the original equation now becomes:

$$I + S = \frac{E - P_oV - \sum \mu_{i_o} N_i}{T_o}$$

$$\therefore \quad I = \frac{E - P_oV - T_oS - \sum \mu_{i_o} N_i}{T_o}$$

This equation can be multiplied by $T_o$ to produce a quantity which EVANS called ESSERGY (for the ESSENTIAL aspect of ENERGY).

$$\text{ESSERGY} = T_oI = E + P_oV - T_oS - \sum \mu_{i_o} N_i$$

The new quantity ESSERGY is useful for measuring the potential available work from energy given in various forms. This quantity, as far as information sciences are concerned, is a measure of the signal/noise ratio for a given system. This is clear since 'signal' is something which must be capable of being differentiated from background noise. Thus in the equation ESSERGY = $T_oI$: when I is small this function deals with INFORMATION but when it is very large, the equation deals with WORK (ENERGY).

The example which Tribus uses is that of a radar antenna.[1] The electromagnetic waves emanating from a radar antenna are composed of electric and magnetic fields. When these vectors are multiplied, their product is known as Poynting's vector. Therefore this product represents radiated power. Power is the rate at which energy flows, or essergy. Very close to a high power radar, the flux of essergy is so powerful that it can be used to cook eggs. However, many miles away, it is discernable to man as a very weak signal of only a few microvolts.

In the future, more use will doubtless be made of EVANS essergy function. The main reason for this is that it is useful in analyzing the economic optimization of power cycles. This enables identification of inefficient energy conversions. Ultimately it will be necessary to make an essergy analysis of all natural energy flows on the earth's surface - particularly the radiant flux conversion mechanisms. It is already evident

1. Tribus and McIrvine, p188

that we are proceeding toward a clash between various competitive processes. Also, since the cost of waste energy dumping is an integral part of energy utilization, this factor is becoming very evident as pollution abatement costs skyrocket. Essergy analysis of all industrial operations will soon become mandatory.

## OBJECTIONS TO USE OF GENERAL SYSTEMS THEORY IN EDUCATION

Some sociologists will vehemently object to the application of 'meaningless mathematical analogies' to any human problems whatever. The isomorphisms found between statistical mechanics, biological systems, and human societies are ridiculed as trivial coincidences of basic arithmetic. Many interdisciplinarians in the past who have tried to explore these possibilities have had personal ridicule directed at them. However, the persistence of observed isomorphisms between various disciplines cannot be simply ignored.

Many objectors have a misconception of the application of General Systems Theory. For example, the laws of gravity apply to apples, humans, and satellites. This does not mean that apples, human beings, and satellites are identical entities.

Similarly, the second law of thermodynamics has been applied to gas molecules, 'bits' of information, and other negentropic structures - including human beings. Obviously it is not intended that a gas molecule be compared to a human being. General Systems Theory merely states that in considering certain specific characteristics of gas molecules, bits of information, and human beings, certain system isomorphisms are evident. And these may be treated by similar systems equations.

## THE ALTERNATIVE TO A GENERAL SYSTEMS APPROACH

If the preceding discussion concerning General Systems Theory and the laws of entropy as applied to education has seemed somewhat unreal, then the only possible alternate philosophy may appear even stranger. In the previous instance, the General Systems Theory assumes an underlying sense of order - an innate rationality to the universe. This rational structure, the laws of physics, the laws of chemistry, the laws of life etc., are assumed to be predictable, rational and knowable. Unfortunately, ALL of these so-called laws are approximations, convenient paradigms or models of man-perceived reality. Not a single one has ever been found to be absolute. Time is not absolute, mass is not absolute, force is not absolute. Even the elementary particles of atoms are not absolute - they are now referred to as waves of probability.

In the midst of all the uncertainty and doubt in the physical sciences, the psychologists have been busy convincing us that our entire internal perceptual world is merely an electrical analog to the external world.

If we assume that the 'underlying' reality external to our senses is an energetic chaos, then we could conclude that all the apparent order we see around us is only a perceived rationality imposed by the genetically developed structure of man's own brain. Consequently there will most certainly be found similar structures in all the appearances of reality as perceived by Man. If this is true, then all perceived structures should exhibit essentially similar characteristics, and that which we normally see as 'reality' would be merely a reflection of the structural organization of our brains. The laws of entropy - the underlying shadows of our daily world, become the collective apparition of Mankind!

For Man to retain his sanity and his purpose in life, he must search for meaning. Thus the alternative to an innately rational universe, is an historic Man-made reality. That which is most real to Man is his historical perception of the external world. Historic as used here, would also include the perception of time and hence the appearance of causality, and hence all the apparent laws of physics, laws of thermodynamics, and apparent laws of economics and social structure.

In order to understand the meaning of this alternative one must consider the two basically different ways of looking at the human paradox. The philosophical concept of 'Materialism' asserts that the fundamental constituent(s) of the universe is matter in motion. On the other hand the concept of 'Idealism' maintains that it is the incorporeal essences or ideas which constitute 'reality'.

The original concept of materialism is difficult to justify today, especially since many physicists have realized that the 'essential' characteristics of 'matter' are simply their perceptions of the various relationships between their own mental constructs which they call 'matter'. There is not one single identity of 'matter' that they have found. They cannot state that 'this' is an electron, or that 'this' is a neutrino. They can only say that 'this' was probably what we have all agreed to call an electron because it behaved in such and such a way when it came near some other 'matter' etc. The neutrino we hardly know at all simply because it refuses to react very strongly with any matter. For all we know there is probably an entire universe full of other things which simply do not react with anything that we are aware of. After all, Democritus did not know that there was a void between atoms - he merely assumed it. The void could well be full. It could easily be some other 'matter' which we simply have not perceived. And further, even the atoms that we thought we could perceive are now to be considered as probable loci of waves within this 'void'. What is there left of 'Materialism'? This leaves us only with our ideas, our mental constructs. These incorporeal essences constitute our mental 'reality'. Thus Materialism, it is seen, can easily become Idealism, and vice versa, depending upon the scientific vogue of the age.

For the individual, there is an out from this vacillating dilemma. It is possible to accept the constancy of change and handle it conceptually - such as Hegel's dialectic method. The individual may at one stage accept the materialistic philosophy, then find some opposing notion more to his liking, and finally incorporate both viewpoints into a new philosophy which supercedes both and moves him on to a higher level of awareness. This spiral process of Thesis, Antithesis, and Synthesis [1] can also be applied to other human activities. For example Kuhn's theory of scientific revolutions[2] assumes a 'normal' science, the appearance of an anomaly, and the emergence of a new 'normal' science etc.

1. Loewenberg. Hegel's selections.

2. Heinich. Technology in the management of instruction. NEA. 1970.

The two world viewpoints can also be called Realism and Idealism. Hegel outlined these as follow:

"Since things and their determinations are in the knowing, it is quite possible, on the one hand, to view the same as in and for themselves outside of consciousness - as given to the latter in the shape of foreign and already existing material for it; - on the other hand, however, for the reason that consciousness is essential to the knowing of these, the view is possible that consciousness itself posits this world, and produces or modifies the determinations of the same, through its mediating relation and its activity, either wholly or in part."[1]

The act of knowing thus involves not only an object alone but the active consciousness of the observer. The various aspects of the object will thus change as the consciousness which perceives it, itself undergoes change. Thus knowledge can only be real as it develops in a systematic form and puts on the mantle of historic authenticity.

In the Hegelian system,---"everything has a rhythmic destiny: it comes to fruition, it comes to grief, it enters a higher truth. Everything vanishes into its opposite, and nothing ever passes away. Under the word AUFGEHOBEN,--- is epitomized the universal law of rhythmic change which everything is fated to exemplify."[2]

As Loewenberg points out, Hegel's dialectic method is one whereby each concept implies its own opposite as a necessary and contiguous part of itself. When both the concept and its opposite are equally perceived by a person, the incongruity can only be relieved by a SYNTHESIS in which a newer and wider concept is generated which can contain both. Thus concepts become more and more complex of structure by process of this multilevel negentropic spiral.

1. Loewenberg, Hegel Selections. p.69
2. Ibid. p xiii

There have been attempts to utilize this method to explain societal growth. The dialectical materialism - idealism of Marx for example sees the societal anomalies in terms of class struggle and in the methods of production of the material conditions of life. In practice, it has resulted in complete catastrophes such as the state-capitalism of Russia and the subjugation of individual freedom by Mao's 'socialist' totalitarian state.

In view of the strength of the worldwide forces which are pushing for social democracy, and the improbable continuation of capitalism through a period of contracting resources, limited available energy, and unavailable pollution dumps, it is necessary to re-evaluate the basic ideals of Hegel's historic humanism as well as the more pragmatic energy-ecology-sociology couplings which could enable continued survival of our species on Earth after the year 2000.

> "--- the right of the whole over the individual, cannot suppress the rights of the family, rights ultimately those of its constituent members. It is thus that the old order changes making way for the new, the new designed to resolve the contradictions inherent in the old."
>
> Loewenberg. p201

## PERSONAL ENTROPY MINIMIZATION

Education in general and 'genetic' education in particular can proceed along either of two divergent paths. Education can decrease individual entropy by increasing the knowledge in one's head or by altering one's genetic structure. Or it could decrease socionomic entropy by allowing individual specialization with consequent increases in societal complexity. Therefore, depending upon how genetic engineering is employed, we could end up with very highly competent individuals who can do everything themselves and thus have little use for highly complex social structures. Or we could end up with very highly differentiated individuals who can exist only within a complex, coordinated cooperative society of specialists.

Keeping in mind the constantly present potential pressure to degrade available energy, the direction of socionomic development must be such that it relieves this pressure. It is for this reason that men band together. As a group it is possible to tap into higher rates of energy flow. Thus the history of mankind shows a twofold pattern of development. First there is the development of genetic structure with each change resulting in a more efficient predator capable of tapping a variety of food (energy) sources. Second, there is the development of more complex socionomic structures, with each change enabling Man to increase his societal and individual energy throughput. Thus the most probable route which will lead us to the imminent future is one where we can anticipate rapid changes in the genetic structures of the race. These will be coupled to equally rapid genetic education (modification) of the flora and fauna which man uses for energy conversions. Unnaturally, this will necessitate radical revisions in socionomic structure.

Entropy minimization by individuals consists of the following activities:

a) Food gathering such as hunting, fishing, farming, or working for energy markers (money). The more food energy one gathers, determines one's rate of physiological growth - up to the limits of biological necessity. Genetic engineering could alter this activity. For example, by eliminating intermediaries in our energy conversion chain (such as cows), it would be possible to have a bale of hay for lunch!

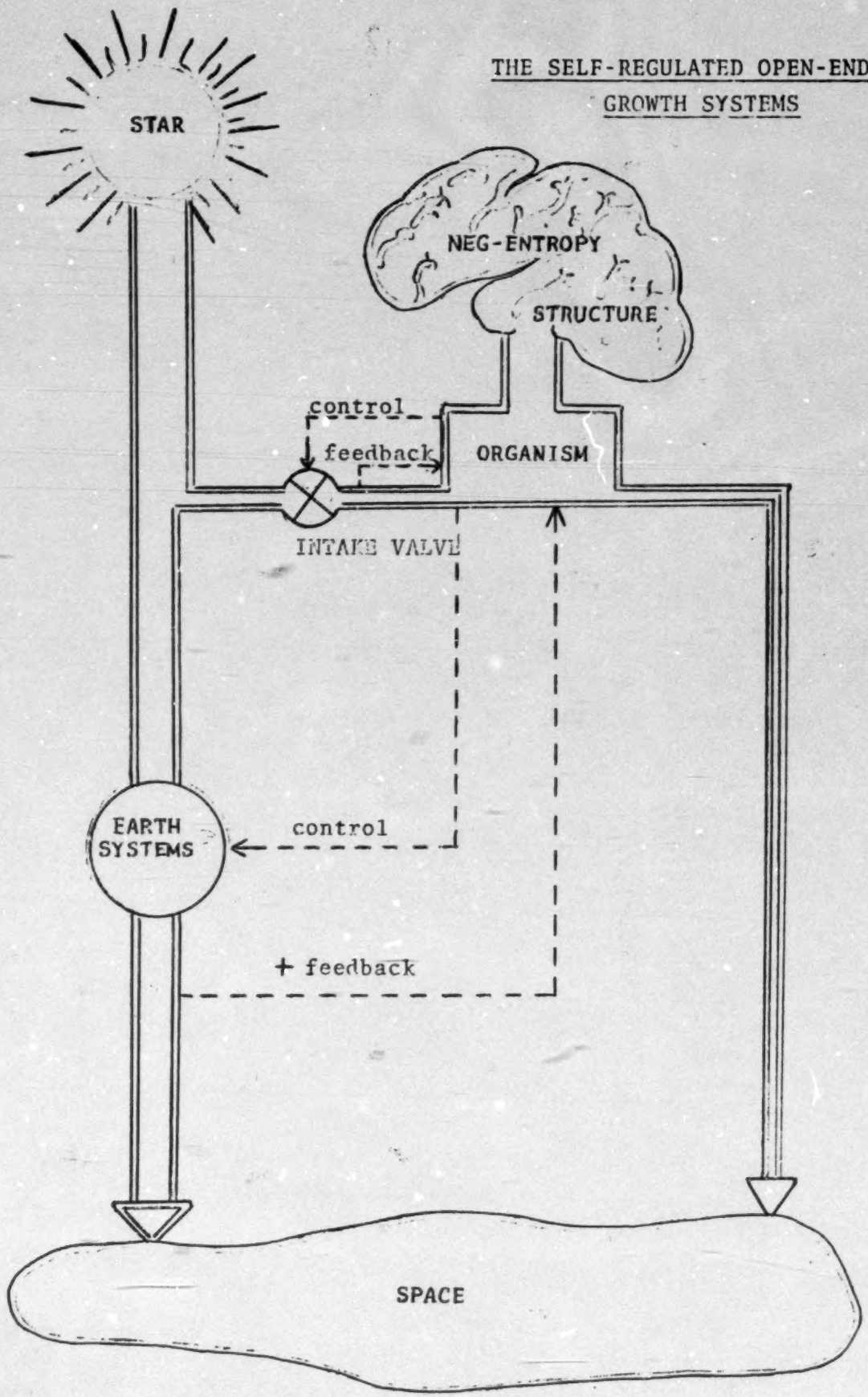
b) Increasing the complexity of mental structures or their surrogates such as books, computer data-banks, etc.

c) Increasing the size and complexity of physiological structures, (including genetic structure). This includes not only normal growth of one's own body but also the propagation of an individual body into hundreds of identical replicas by process of cloning. Most of man's energy converters are already being propagated in this manner. For instance apple trees etc., where entire orchards can consist of literally thousands of genetically identical trees. The next stage will be cloning of beef steers directly from prize bulls, thus eliminating the need for carrying females. This process has not yet been successful with mammals but once it is perfected for cows, it will become possible for man.

d) Building of physical structures such as houses which provide shelter and enable growth of physiological structure in a controlled environment. Building of schools, TV sets, libraries etc. which enable growth of mental structure. Building of workshops and factories to house the machinery of man's technostructure.

The individual organism utilizes available energy flows, (mainly energized by sunlight), to tap off variable quantities for its own use. Generally, each of the entropy minimizing activities result in some neg-entropic structure being formed. A plate full of food, a book, a thought, the human body, houses, schools, and factories, are all examples of neg-entropic structures.

In order not to be burned to a cinder by the positive through-flow of large amounts of energy, the organism must maintain a feedback link to operate its intake valve (mouth etc.). Similarly, a more sophisticated animal such as Man must also maintain feedback control on his control of other Earth surface energy flows. This is the reason why education is very important. An uneducated individual could easily pollute his immediate environment because most Earth systems energy flows do not have an inherent negative feedback control built into Man - such as the nerve sensors in his stomach. Man will close his mouth before he stuffs himself to death with food, but he may well turn on all Earth system energy taps and pollute himself to death.


THE SELF-REGULATED OPEN-ENDED
GROWTH SYSTEMS
STAR
NEG-ENTROPY
STRUCTURE
control
feedback
ORGANISM
INTAKE VALVE
EARTH
SYSTEMS
control
+ feedback
SPACE

## INDIVIDUAL vs. COLLECTIVE ENTROPY REDUCTION

There has always been and there will always remain a divergence between the needs of social entropy reduction and individual entropy reduction. The balancing of this equation has been attempted by many - from John Stuart Mill to Mao.

> "Socialist revolution aims at liberating productive forces. The change-over from individual to socialist, collective ownership in agriculture and handicrafts and from capitalist to socialist ownership in private industry and commerce is bound to bring about a tremendous liberation of productive forces."[1]

Another quotation by Mao will illustrate how this works in practice:

> "The spontaneous forces of capitalism have been steadily growing in the countryside in recent years, with new rich peasants springing up everywhere and many well-to-do middle peasants striving to become rich peasants." etc...[2]

The struggle is apparently forever!

It is evident that anarchy, warfare, revolutions etc. (states of increasing entropy), which do not result in new more complex socionomic structures which in turn, are capable of enabling more sophisticated utilization of available energy sources, and which do not facilitate the building of new neg-entropic structures for INDIVIDUAL members of the society, will in their turn also give rise to further revolutions. Mao states that:

> "Changes in society are due chiefly to the development of internal contradictions,... it is these contradictions that push society forward and give impetus for the supersession of the old society by the new."[3]

This statement is of course Hegel's dialectic method given in terms of social materialism rather than individual development.

It is a fact that individual entropy reduction or individual human development is the prime mover of socionomic change - whether evolutionary or revolutionary. In practice, the reverse has not been demonstrated. Only if most individuals in a society benefit by socionomic change, that is, benefit in terms

1. Quotations from Chairman Mao Tse-Tung. Bantam Books, N.Y. p.14.
2. Ibid. p.18.
3. Ibid. p.5.

of lower personal entropy levels produced by higher energy throughflow, will the socionomic structure become temporarily stable. Permanent stability is of course a theoretical impossibility since an increase of structure of any kind, is but a local and transient reversal of the natural energy degradation process in the universe.

Analyses of energy throughflows in societies with different basic socionomic structures are very illuminating. Kemp analysed energy flow in an Eskimo village on Baffin Island in the Canadian Arctic. All energy inputs were measured in terms of kilocalories, and all expenditures likewise noted. It was possible to draw a chart showing all flows within a given household.[1] There is a basic similarity between the more primitive hunter fuelling his snowmobile for a day's hunt, and the urban apartment dweller who drives off in his car for a day's hunting for energy markers (dollars).

Another analysis has been carried out by Rappaport on the energy flows within an agricultural society.[2] Not only were energy flow rates measured for the Tsembaga farmers in New Guinea but some very interesting socionomic observations were also made. Rappaport believes that as an ecosystem matures, the increasing specialization of individual species reduces overt competition and increases mutual dependence.

> "In effect, as the ecosystem becomes maturer it becomes more complex for the number of species, and their interdependence increases. As its complexity increases so does its stability, since there are increasing numbers of alternative paths through which energy and materials can flow." [3]

The analysis in comparison points out some disquieting characteristics of our own farm management. Most Canadian farmland is devoted to monoculture.

That is, one type of plant is grown for a hundred or even thousands of acres. The reason is of course to enable mechanical planting and harvesting and thus increase the output yield in comparison to input energy. However, these ecosystems are extremely delicate and highly unstable. One infestation of Bertha worms can wipe out thousands of acres of crops. Of course, increased specialization and higher energy conversion efficiency allows for more energy to enable more complex human socionomic structures as well as dense populations. It would be impossible for present society to revert to Tsembaga technology. However, Rappaport

1. W.B.Kemp, The flow of energy in a hunting society. Scientific American. Sept. 1971. Vol.224 #3. p.109.
2. Roy A. Rappaport, The flow of energy in an agricultural society. Scientific American. Sept.1971. Vol.224 #3. p.117.
3. Ibid. p.130.

asks:

"if worldwide human organization can persist and elaborate itself indefinitely at the expense of decreasing the stability of its own ecological foundations." [1]

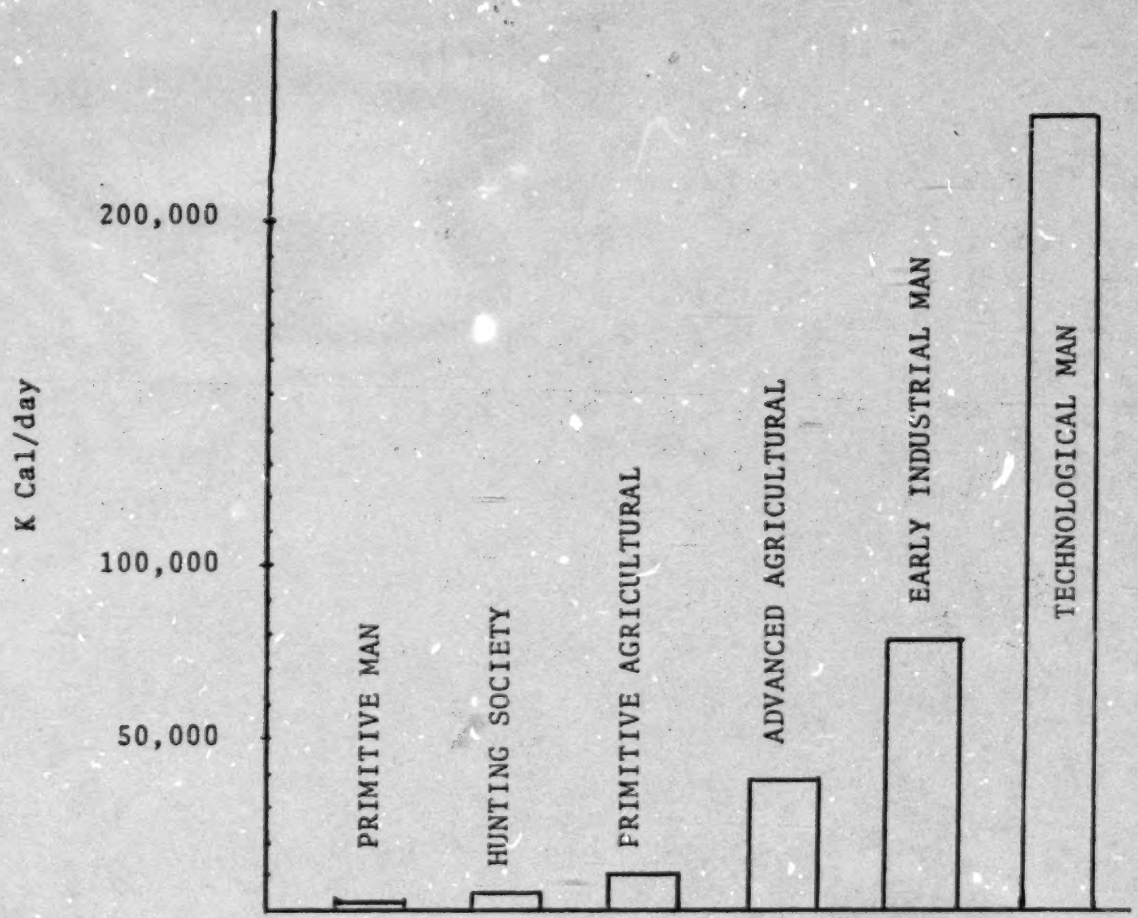



Fig. 19. DAILY PER CAPITA ENERGY CONSUMPTION [2]

1. Roy A. Rappaport, The flow of energy in an agricultural society. Scientific American. Sept.1971. Vol.224,#3. p132.
2. Earl Cook, The flow of energy in an industrial society. Scientific American. Sept.1971. Vol.224,#3. p136.

The flow of energy in an industrial society is illustrated by Earl Cook's analysis of flow patterns in the United States.[1] The most startling characteristic of the industrial society is the rate at which energy is used or degraded. The basic biological need for food energy is satisfied by about 2,000 kilocalories/day/per person. Using up heat to cook this food can raise this total to about 4000 kcal/day. In a primitive agricultural society 12,000 kcal/day may be used. The use of farm machinery may bring this to about 20,000 kcal/day. At the beginning of industrialization energy consumption in England around 1850 may have reached 70,000 kcal/day. With the advent of central power generating stations and the internal combustion engine, the individual can consume more than 230,000 kcal/day.

Whereas the socionomic structures for both the hunting society and for the agricultural society can remain in balance with their ecosystems, the rules for energy utilization for the U.S. industrial complex have been historically determined by individual and corporate avarice for personal entropy reduction. It is obvious that this reduction in entropy has been achieved at the price of capital energy degradation. That is, the capital reserves of fossil fuels (stored sunlight) are being rapidly exhausted. In 1970, 96% of the gross energy input into the U.S. economy was through the use of non-renewable oil and gas reserves.[2]

In any case, by the year 2000, the effects of waste heat will start causing more problems than finding new energy sources. Previously it was pointed out that Man needs not only energy but AVAILABLE energy. If there is no heat sink to dump the waste energy, then flow cannot take place. And without energy flows, living matter will decompose into inanimate forms (increased entropy). Thus it will be essential to find atmospheric windows to radiate waste heat out into space. Perhaps this will ultimately be done by low frequency microwave beams.

In the meantime it is becoming clear that 'laissez-faire' economic expansionism by individuals and corporations has become obsolete. It is also clear that the naive utopian application of Marxian theory is not a viable alternative either.

It is time to consider the type of balance any given society wishes to achieve between individual and societal entropy reduction needs and work out the appropriate socionomic laws to help maintain a state of equilibrium between Man and his ecosystem.

1. E. Cook. The flow of energy in an industrial society. Scientific American. Sept.1971. Vol.224 #3. p.135.

2. Ibid. p.135.

For this purpose it will be necessary to give 'values' to the various activities which man performs in an industrial society. A starting point may be to develop this value system in terms of societal entropy reduction. A hierarchy of neg-entropy enhancers in terms of their information amplification power can be attempted. One sketch of this type is depicted by the diagram suggesting a possible HIERARCHY OF ENTROPY ENHANCERS.

In this model, individual neg-entropy structures can be built by many parallel organisms feeding in parallel off a main energy stream (fossil sunlight). Information links (neg-entropy markers), are shown vertically. The number of links between succeeding levels indicates possible amplification of signals between levels. It should be pointed out that the signal amplification could also be negative, or a signal may be progressively attenuated on its way from the top down. This explains why not all philosophers are kings - but the ones which are, are very powerful indeed!

It has been (satirically) proposed that genetic engineering will be used to produce a highly differentiated class structure. This degree of specialization into kings, managers, designers, engineers and technicians may indeed result in a high degree of socionomic stability. Present instabilities are certainly at least partly due to lack of vertical mobility in genetically competent individuals. Communication and education are information transmission methods whereby increasingly complex banks of information (neg-entropy) can be accumulated, and increasingly complex socionomic structures can be sustained. The exchange of information enables specialization of function, which in turn aids increased industrial activity or energy flow through the society.

In this light, a university education tends to reduce the levels of PERSONAL ENTROPY, regardless of the ability of this education to facilitate greater or more efficient societal energy flows. For this reason, high costs are not necessary for the production of a general education. In fact many more efficient ways are being tried - such as the OPEN UNIVERSITY via TV in Britain. College education or a practical-technical education has as its purpose a reduction of personal entropy only insofar as it will immediately enable the individual to assist in accelerating the rate of increase of environmental entropy. Community college education as it is presently institutionalized is primarily suited to an expansionist economy with increasing rates of individual and industrial energy consumption. Since the emphasis

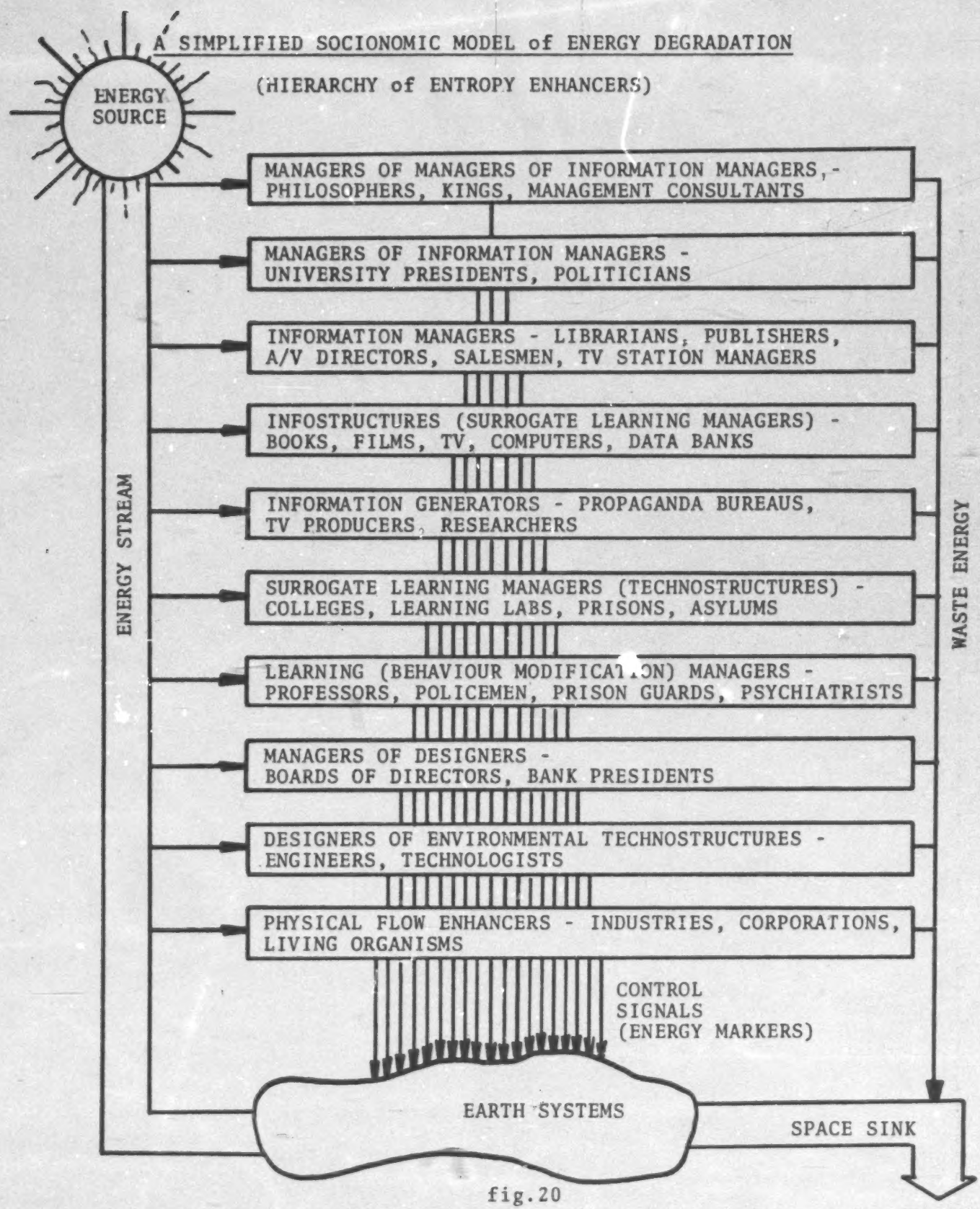

A SIMPLIFIED SOCIONOMIC MODEL of ENERGY DEGRADATION
(HIERARCHY of ENTROPY ENHANCERS)
ENERGY SOURCE
MANAGERS OF MANAGERS OF INFORMATION MANAGERS, - PHILOSOPHERS, KINGS, MANAGEMENT CONSULTANTS
MANAGERS OF INFORMATION MANAGERS - UNIVERSITY PRESIDENTS, POLITICIANS
INFORMATION MANAGERS - LIBRARIANS, PUBLISHERS, A/V DIRECTORS, SALESMEN, TV STATION MANAGERS
INFOSTRUCTURES (SURROGATE LEARNING MANAGERS) - BOOKS, FILMS, TV, COMPUTERS, DATA BANKS
INFORMATION GENERATORS - PROPAGANDA BUREAUS, TV PRODUCERS, RESEARCHERS
SURROGATE LEARNING MANAGERS (TECHNOSTRUCTURES) - COLLEGES, LEARNING LABS, PRISONS, ASYLUMS
LEARNING (BEHAVIOUR MODIFICATION) MANAGERS - PROFESSORS, POLICEMEN, PRISON GUARDS, PSYCHIATRISTS
MANAGERS OF DESIGNERS - BOARDS OF DIRECTORS, BANK PRESIDENTS
DESIGNERS OF ENVIRONMENTAL TECHNOSTRUCTURES - ENGINEERS, TECHNOLOGISTS
PHYSICAL FLOW ENHANCERS - INDUSTRIES, CORPORATIONS, LIVING ORGANISMS
CONTROL SIGNALS (ENERGY MARKERS)
EARTH SYSTEMS
SPACE SINK
ENERGY STREAM
WASTE ENERGY

fig.20

is changing away from this socionomic norm, the nature of college courses will likewise have to alter. We need to train citizens who are more aware of their societal obligations. We need people who understand how to make efficient use of food energy. We need waste-disposal-pollution experts, a neglected area which is exactly as important as the original energy production in the first place. We need people who will understand the principles of genetics and all the other complex arts of child-rearing. Most of these things are not funded as proper college courses because they do not appear at present to be activities which enhance the G.N.P!

The profitability of investment in different programs varies with time. In an expansionist economy, with a surplus supply of available energy, there is an obvious need to train technicians, technologists, and engineers. When all that is necessary is to drill a hole in the ground and tap the oil flow, it is easy to support technical universities and train quantities of technologists to run the fossil technostructure. However, when the entropy dumps begin to fill (air pollution, water pollution, environmental thermal pollution), the educational info.-structure must process new types of energy flow enhancers. These will include research scientists studying new energy sources and sinks, pollution control technicians, resources conservation technicans, materials recycling engineers, social stress abatement technologists, sunlight conversion technicians (farmers etc.), space technologists, and genetic engineers, human growth and development specialists (mothers), just to name a few.

In a TOTALITARIAN STATE, if all people were actually born equal it would suit the entropy model since each would then be apportioned an equal share of input energy. However, in a Democratic society it must be assumed that all men are born of unequal ability. Thus it is necessary to guarantee vertical mobility within such a society. This will ensure that those with superior ability will in fact reach those societal neg-entropy levels suitable to their talents.

It has been shown by many researchers that the educational opportunity is unfortunately much less in Canada for those students who are children of manual workers or whose parents are of below average economic status. No matter what teachers or schools do, they cannot remedy this situation by themselves. There really are only three known alternatives to remedy this unfortunate situation. First, there is the solution which is common to more socialistic societies. This entails large scale operation of day-care centres w.th highly competent staff.

The child is in fact removed from the home influence for long periods of time, starting at a very early age. Secondly, there is the possibility of retaining the family unit, but giving professional training to all prospective mothers. This training would cover a wide spectrum of family-life sciences. Subjects would probably include home economics, nursing, early childhood education, developmental psychology etc. All courses would be at the college level and compare in depth with courses given to other girls who make their careers in nursing, home economics or early childhood education. Finally, there should be proper salaries paid to all mothers commensurate with their skills, training and experience. Otherwise, it would be futile to educate people for a profession which is improperly remunerated.

The education of farmers illustrates another part of the same problem. Very few farmers would even recognize the scientific description for their job - thermonuclear radiant energy diversion through biological energy conversion mechanisms for the production of complex hydro-carbon compounds enabling energy storage, to compensate for cyclical radiant flux variations, to sustain required energy input levels and energetic environments for self-replicating colonies of second level organisms. Most farmers would only understand this process when it is put in very every day terms such as:- Use sunlight to grow grass, cut the hay and store it in a barn so that it can be fed to the cows during winter! To illustrate that the preceding is not just an amusing play on words, consider the word 'diethylstilbestrol'. In farm terminology it was simply DES. One fed DES to cows to get them fatter for market. However, diethylstilbestrol is the female sex hormone and is known to produce cancer. It was only recently banned from livestock feeds.

The fact that neither farming nor child-rearing require minimum standards of education while the "skilled" tradesmen such as plumbers, electricians and plasterers etc. all have specific and enforced legislation governing periods of apprenticeship and education, simply emphasize the perverse character of the present socionomic system.

## EDUCATION FOR THE FUTURE

It is possible to follow one of two paths leading to the future. It is possible to proceed forward with an historical perspective. This entails projections of past value systems on-to future contingencies. Whether this will work or not depends upon how different the future is from the past. If everyone follows this route, the future may become a self-fulfilling prophecy in that it will remain the same as the past. Even the dialectic does not allow a revolutionary divergent future. It too must incorporate segments of the old order to create the new. It also is an historical process.

In opposition to the historic route there is the alternative of the futurists. It consists of a constant scanning of future alternative, a constant calculation of future probabilities, an heuristic search of past facts to find the new and the possible combinations. The method is as corrosive to mental stability as the constant rejection of old levels of understanding in the dialectic method.

Toffler points out that things, places, people, organizations, and information constitute the basic components of all human situations.1. It is these essential ingredients which have for contemporary man, assumed a new level of transience. Thus our expectations based on our historical past no longer map out future probabilities. The future has become too different from the past.

In order for man to cope with the onrush of the time-telescoped future, Toffler wishes to prepare men by educating them to contemplate the future.

"The present curriculum... is not based on any well thought out conception of contemporary human needs. Still less is it based on any grasp of the future, any understanding of what skills Johnny will require to live in the hurricane's eye of change. It is based on inertia - and a bloody clash of academic guilds, each bent on aggrandizing its budget, pay scales and status." 2.

It is certainly true that a great deal of effort is spent on spatial orientation of the student. That is, he is taught geography with respect to his town, his province, his country and the world. But the student's time orientation is solely between the remote past and the immediate past.

1. Toffler,A. Future shock. p.43.
2. Ibid. p.364.

The immediate consequence of this backward viewpoint is our constant frustration over deplorable events. Our politicians allow Canadian resources, water, land and energy to be sold off to the highest bidder. The fact that their own children will live to curse their stupidity has obviously never been considered. Toffler pleads that -

"If our children are to adapt more successfully to rapid change, this distortion of time must be ended. We must sensitize them to the possibilities and probabilities of tomorrow. We must enhance their sense of the future."3.

3. Toffler,A. Future shock. p.375.

## EVOLUTION AND EDUCATION

The theories of evolution which utilize processes of selection, competition, and survival of the fittest, all make the assumption that self-maintaining, self-replicating systems already exist. Furthermore, it has been stated that there are no known laws of physics which would predicate that, even if such systems did exist, they would proceed to develop in the direction of increased organization. It is possible to speculate that the basic 'life instinct' is in fact not one of survival per se, but rather the most basic instinct is one which simply demands an energy throughput.

If a potential of available energy exists at a given location, then the natural directive laws of thermodynamics call for increased entropy. If an 'unnatural' energy short-circuit does occur because of this thermodynamic pressure (i.e. the chance appearance of living, organic compounds in a primeval ocean), these new flows could be considered as energy flow short-cuts and would behave as open systems transporting energy to lower levels of increased entropy. Continuing thermodynamic pressure would favour the development of similar parallel systems. Thus it favours the presence of self-replicating systems, because these have a much higher probability of increasing energy flows toward maxentropy.

Once similar parallel systems, (species), start competing at the same energy stream, they must store increasingly greater amounts of information (genetic templates), in order to be able to extract energy from a finite source of supply. Thus the evolution of more complex organisms is probably the result of periodic energy crises. These energy crises occur whenever a sufficiently overabundant number of the same species over-populates the banks of their basic energy stream. In the event that two species develop such that both feed off the same type of energy stream, the species which achieves the greatest through-flow of available energy, will starve off the other. This can be accomplished in several ways such as a very high reproductive rate, infallible defence mechanisms, or a very high individual energy utilization rate. In the case of Man, his stomach is a very flexible energy converter which can utilize the flow from multiple energy streams (food types), such as vegetables, meats, fish, birds etc. Thus Man can, and will, cause the extinction of many other species. The species which will survive are those which do not compete at the same energy stream as Man. For example, apple trees (direct sunlight energy flow) and cows (conversion of cellulose fibre to meat).

This is of course obvious since Man cannot eat sunlight nor can he eat grass. However, Man can eat grass seeds. Hence wheatfields can displace grassland and extinct the buffalo. Therefore, when Man changed from hunter to farmer, he made additional energy streams available to him. This enabled human population to increase and some other species were extinguished.

The age of technology is an intermediate stage in Man's evolution. The basic energy conversion plans inherent in his genetic infostructure have changed little in the last century. However, a surrogate change has taken place in lieu of genetic change. Man has designed artificial infostructures such as books, computer memories, videotapes, holograms, etc. These act as additional schemata to enable new energy conversion technologies. For example, Canadians now extract two million barrels of oil per day. One million is used for feeding the Canadian technostructure (mechanical templates for latching on to energy streams - i.e. oil pipelines). The other million is streamed away to parallel energy consuming systems in the United States. This oil is a negentropy memory of stored sunlight from two hundred million years ago. It has been a source of potentially 'available' energy for millions of years which has now become available to Man through his artificial infostructure which enables design of an oil eating technostructure. If Man had become genetically altered such that he became an oil eater, and if the oil supply became depleted within one generation (estimated world supply is 50 years), then the human species would have evolved into termination.

The most devastating technological developments concern the direct conversion of sunlight to energy flows available for human utilization. The most common example of this is the sunlight-gravitational-hydro-electric energy conversion chains. Worse yet to come are photo-electric power cells etc., which will compete directly with ALL plant and animal life in the direct capture of sunlight. Thus it becomes fairly obvious that when Man finally becomes civilized, he will be able to adapt himself to available energy streams through genetic engineering. Adaptation to local variations in energy streams will still be dealt with by surrogate changes in his (external) infostructure. For example, civilized Man will need to leave the Earth's biosphere and adapt himself to space colonies. The main energy through-flow in these colonies will be the same as on Earth, i.e. sunlight capture-conversion-work-waste energy re-radiation (infra-red) back to space on the 'night' side of the colony (technostructure). Because Man will still need food energy, and because it will be difficult to develop a radiation

capture-conversion skin (such as plant leaves have), he will depend on an external stomach such as greenhouse-satellites. These will probably grow green simple-cellular organisms which could be compressed into food tablets. The new genetically altered men or meta-men will then have smaller stomachs, and very weak limbs etc.

The new society of meta-men will probably become involved with attempting to harness the most fundamental source of energy in our galaxy. This is the gravitational rotation of the Milky Way. Since the energy conversion capabilities of 'meta-men' lie beyond the limited boundaries of present human comprehension it is difficult to speculate further at this time.

It is clearly evident however, that in the future, the nature of 'education' will be two-fold. First there is the education of the species through genetic engineering (genetic infostructure). Second, there will be the temporary education (construction) of individual mental infostructures.

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